ASTRONOMY

January 1981
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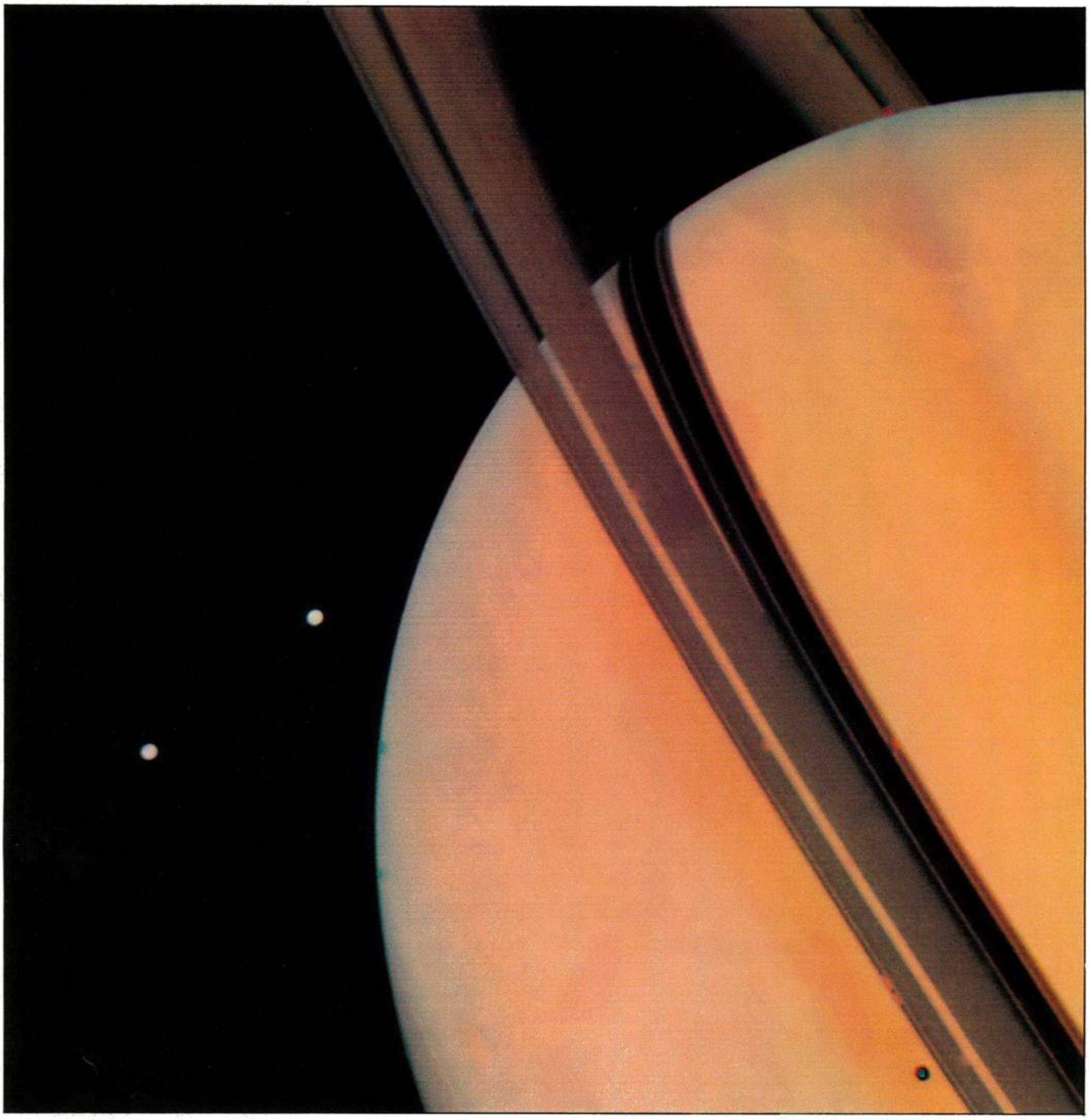
Saturn: The Voyager Encounter

The Future of Space Astronomy

Is the Universe Spinning?



Saturn, Tethys & Dione

Meade System 2000

Think of the dimensions a truly research-quality instrument would add to your observing program.

Then consider moving up to the quality and performance of a Meade 4-inch or 8-inch Schmidt-Cassegrain. For Meade Schmidt-Cassegrains, both optically and mechanically, really are the finest instruments of their kind ever offered the serious observer and astrophotographer.

And, as parts of a wide-ranging system, they are instruments that will grow with your expanding horizons.

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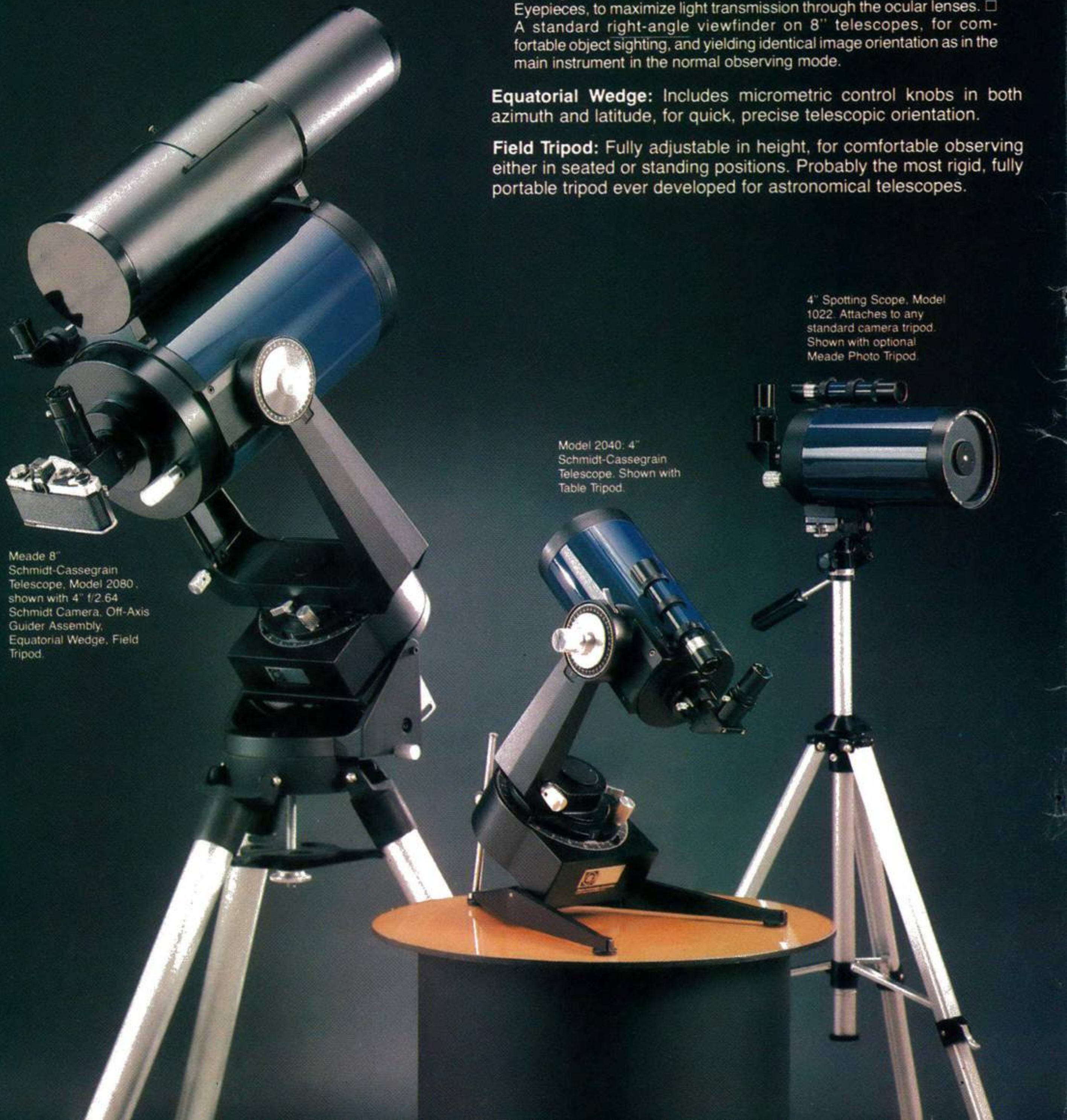

4" Spotting Scope, Model 1022. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

Model 2040: 4" Schmidt-Cassegrain Telescope. Shown with Table Tripod.

Meade 8" Schmidt-Cassegrain Telescope, Model 2080, shown with 4" f/2.64 Schmidt Camera, Off-Axis Guider Assembly, Equatorial Wedge, Field Tripod.

Schmidt-Cassegrains

The System: Perhaps most importantly of all, Meade System 2000 Schmidt-Cassegrains are part of a wide and versatile system: the amazing 4" f/2.64 Schmidt Camera; 4" Schmidt-Cassegrain Photo-Guide Telescope with Illuminated Reticle Eyepiece; Dual-Axis Drive Corrector, and more — all of which attach easily and directly to 8" models.

Aesthetic Design: In the beauty of their enameled deep-blue tube surfaces, in the fineness of their machine-tooled mechanical components, Meade System 2000 models are light years ahead of the competition. See the System 2000 for yourself, and no further explanation will be necessary.

Warranty: As with all Meade products, the System 2000 is fully covered by the Meade One-Year Limited Warranty. See the Meade catalog for full details on this no-risk protection of your investment.

PRICE LIST

Model 2040:	
4" Schmidt-Cassegrain Telescope with Fork Mount ...... Base Price	**$545**
Model 2080:	
8" Schmidt-Cassegrain Telescope with Fork Mount ...... Base Price	**785**
Equatorial Wedge 4"/8"	**50**
Field Tripod 4"/8"	**140**
Table Tripod 4"	**35**
Table Tripod 8"	**45**
Model 1020: 1000mm f/10 Telephoto Lens	**325**
Model 1022: 4" Spotting Scope	**395**
Meade Photo Tripod for Models 1020 or 1022	**50**
Model 2066: 4" f/2.64 Schmidt Camera	**435**

All prices include packing. Complete telescopes are packed in luggage-quality foam-lined carrying cases. All prices F.O.B. Costa Mesa, California. Calif. residents add 6% sales tax.

Catalog: Send $3.00 (Outside North America $5.00 for air mail) for your copy of the new 48-page Meade Color Catalog **No. 80-C**, with full details on Meade Schmidt-Cassegrains, Newtonian reflectors, refractors, accessories.

Orders: May be placed by mail, or by telephone at **(714) 556-2291**, or visit our Costa Mesa factory/showroom.

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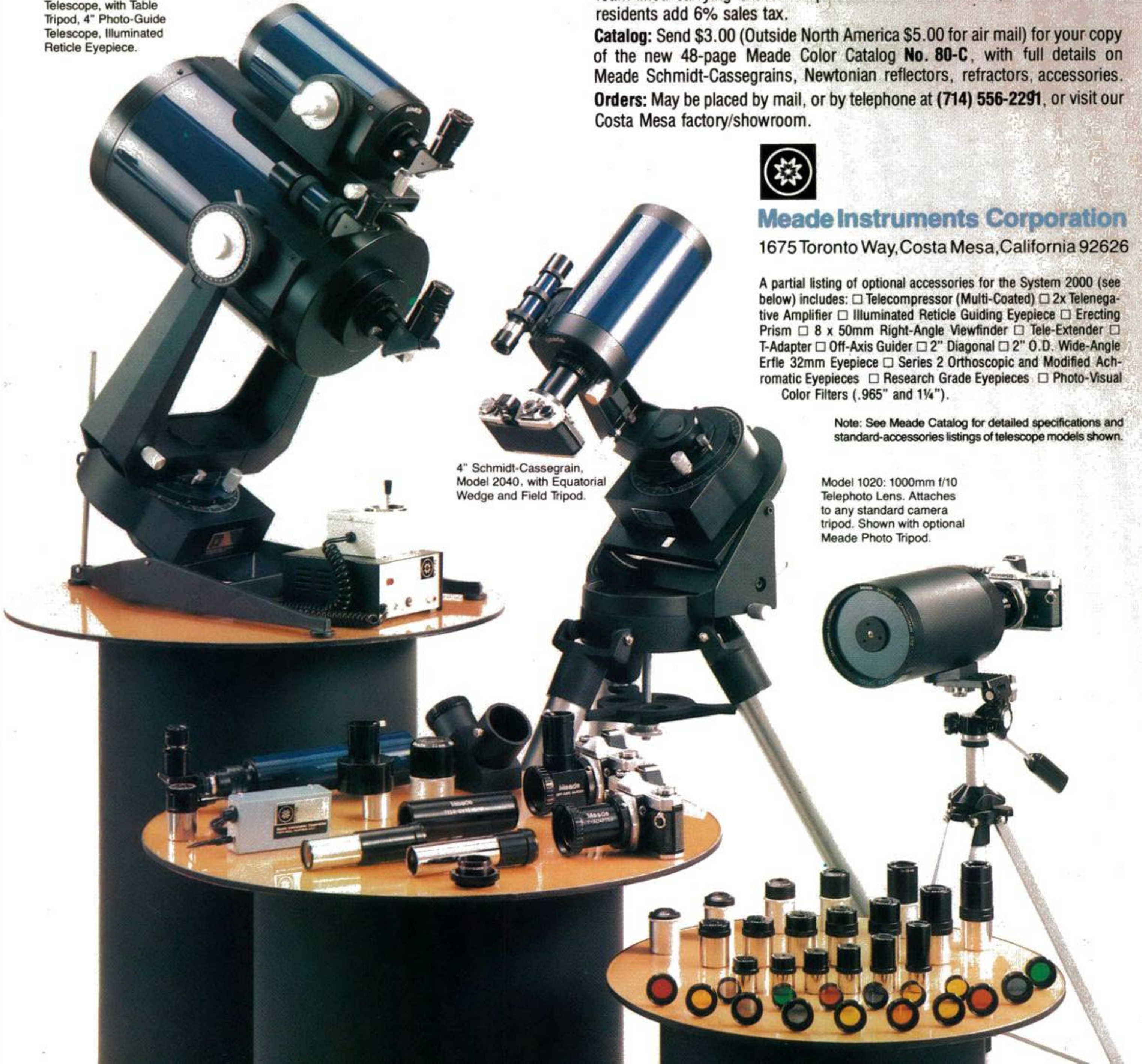
A partial listing of optional accessories for the System 2000 (see below) includes: ☐ Telecompressor (Multi-Coated) ☐ 2x Telenegative Amplifier ☐ Illuminated Reticle Guiding Eyepiece ☐ Erecting Prism ☐ 8 x 50mm Right-Angle Viewfinder ☐ Tele-Extender ☐ T-Adapter ☐ Off-Axis Guider ☐ 2" Diagonal ☐ 2" O.D. Wide-Angle Erfle 32mm Eyepiece ☐ Series 2 Orthoscopic and Modified Achromatic Eyepieces ☐ Research Grade Eyepieces ☐ Photo-Visual Color Filters (.965" and 1¼").

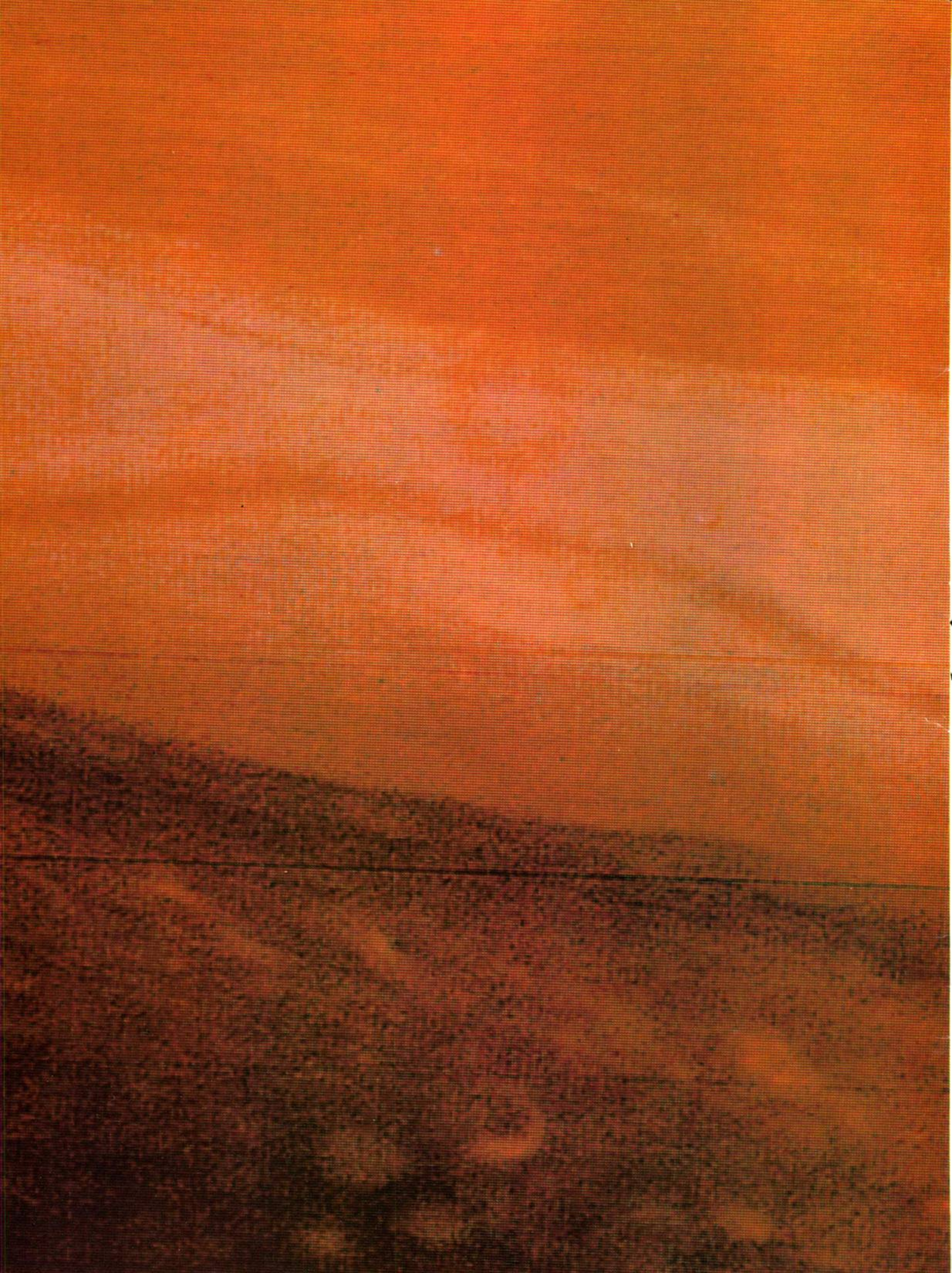
Note: See Meade Catalog for detailed specifications and standard-accessories listings of telescope models shown.



Model 2080: 8" Schmidt-Cassegrain Telescope, with Table Tripod, 4" Photo-Guide Telescope, Illuminated Reticle Eyepiece.

4" Schmidt-Cassegrain, Model 2040, with Equatorial Wedge and Field Tripod.

Model 1020: 1000mm f/10 Telephoto Lens. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.



ASTRONOMY

Vol. 9, No. 1 January 1981

The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther

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Cover: On November 3rd, when the Voyager 1 spacecraft was 13 million kilometers away, it photographed Saturn and two of its moons, Tethys (above) and Dione. The dark shadows of Tethys and the rings show clearly on the ball of the planet; the large gap in the rings is Cassini's Division. These pages: In this photo of Saturn's mid-northern latitudes, there's a dark area marking the trace of a westward (leftward) flowing jet stream below, while at top, ribbony cloud structures meander along. NASA/JPL photographs.

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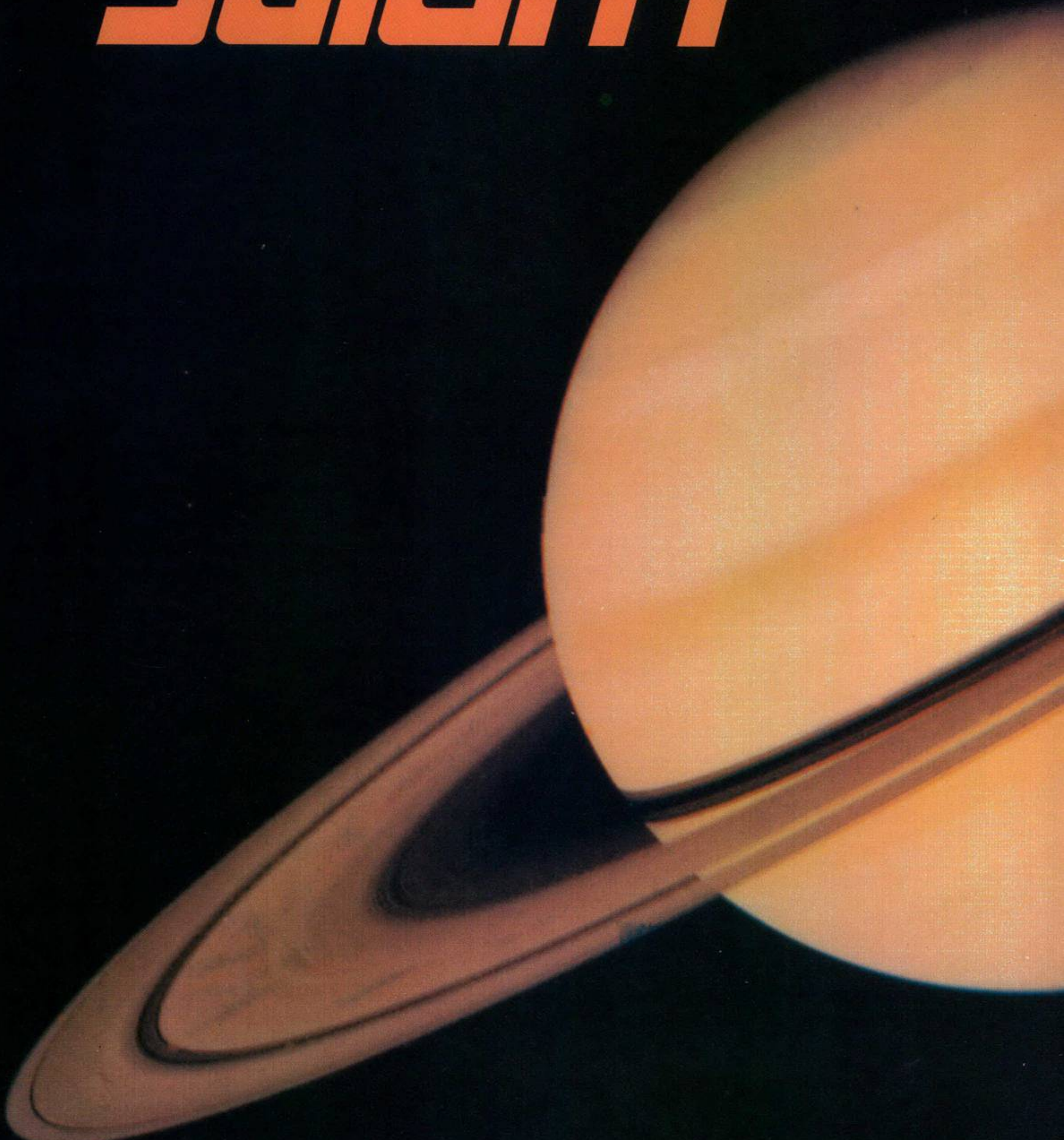
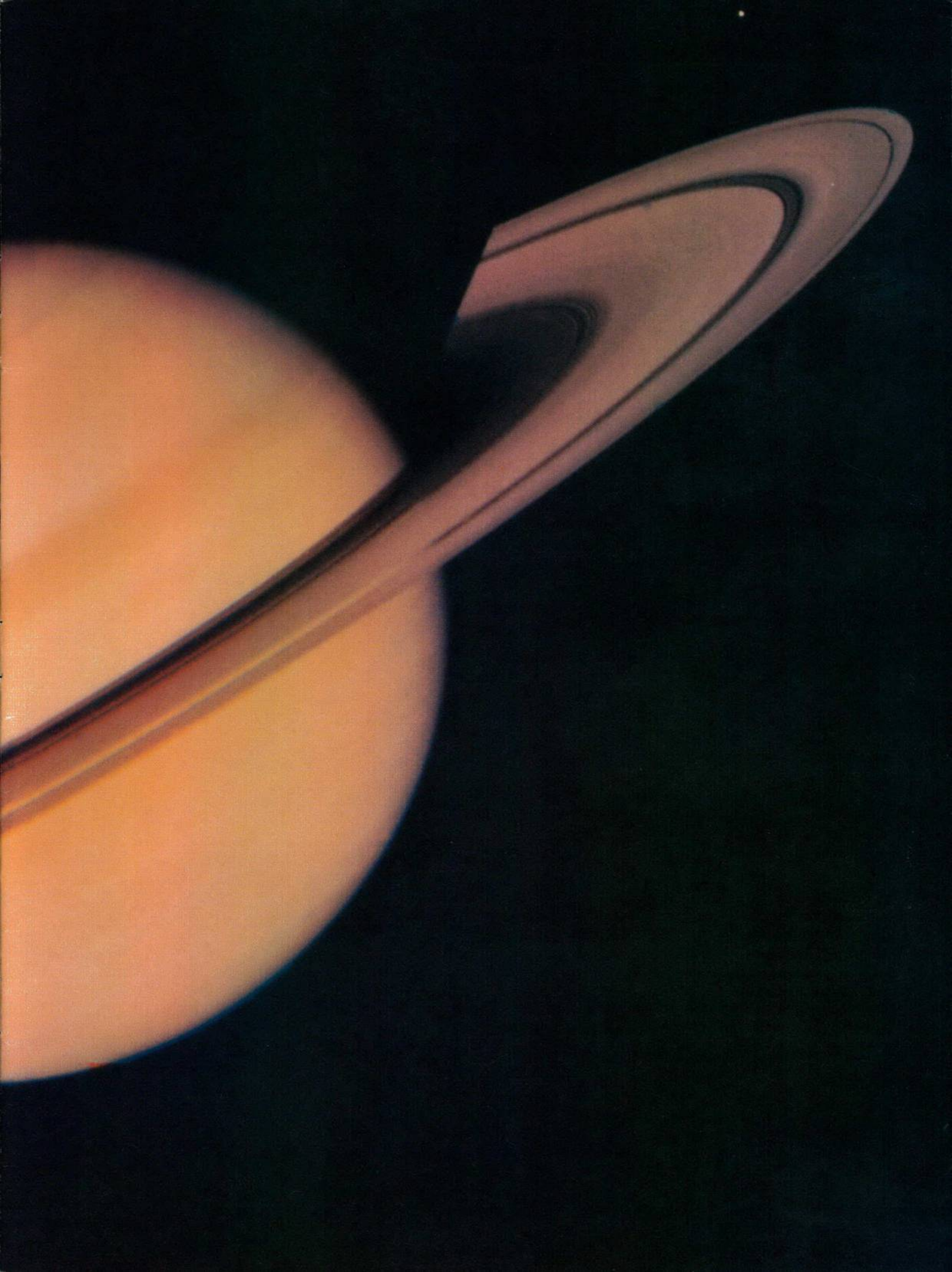
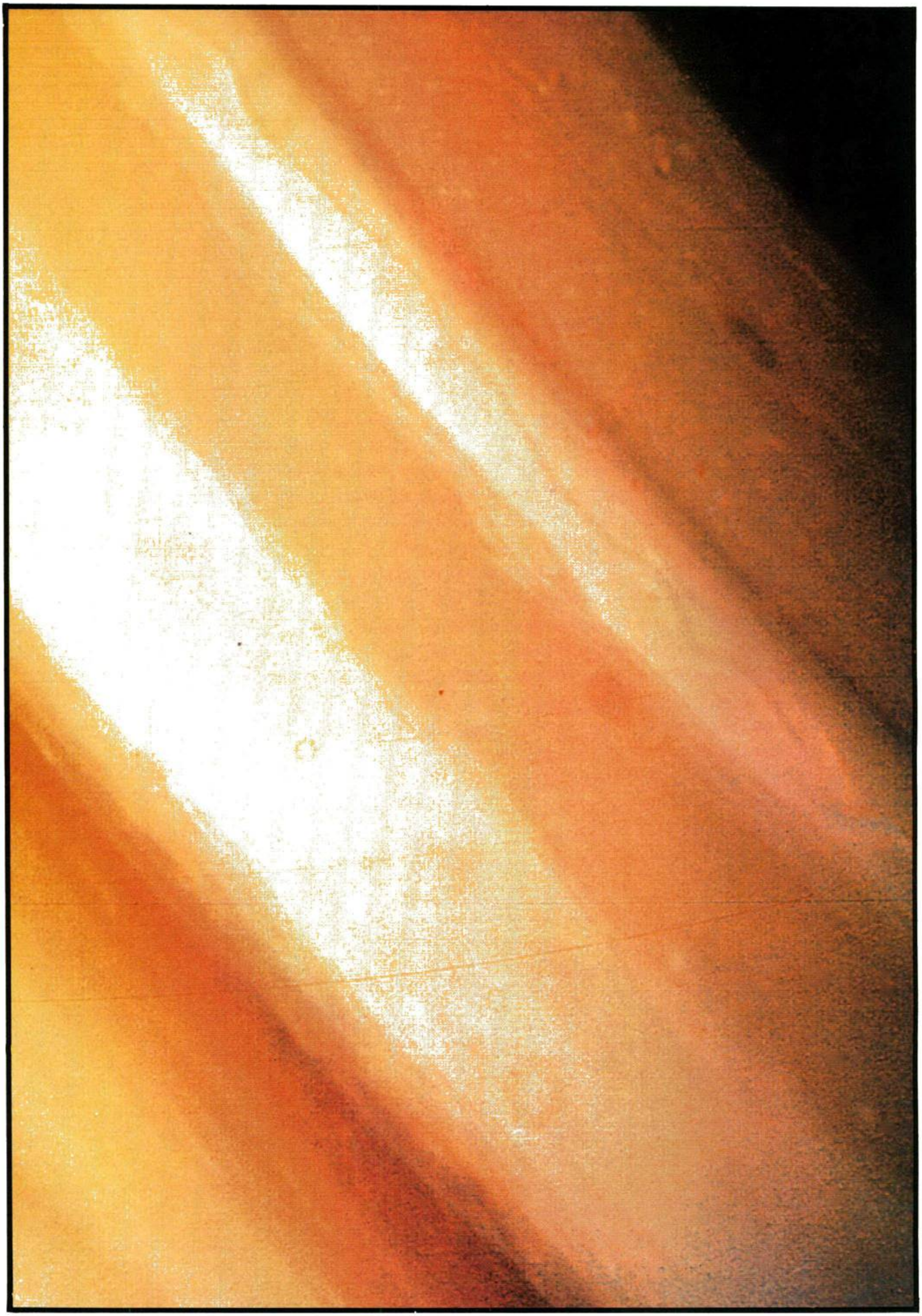
VOYAGER ONE AT
Saturn







VOYAGER ONE AT Saturn

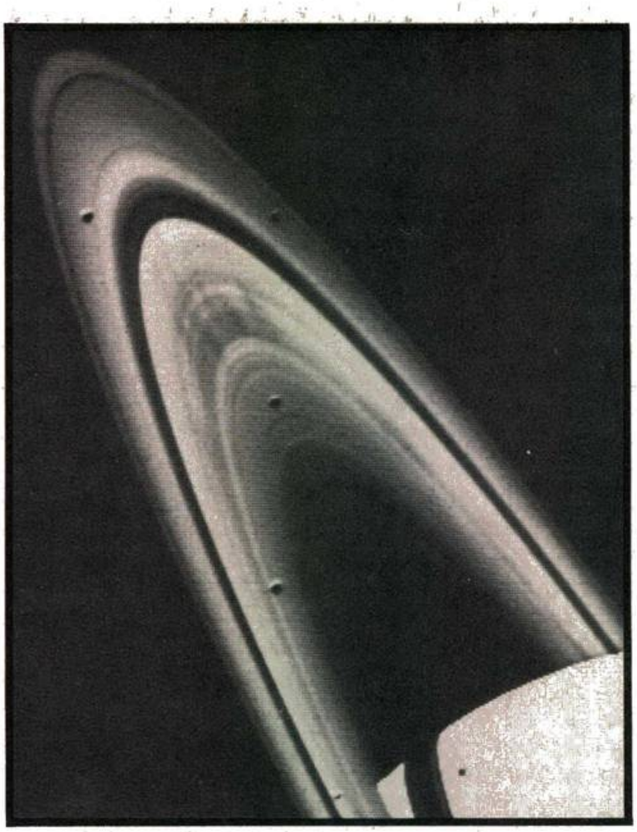
A brilliant gathering of planets hung in the morning sky. Brightest was the Moon, a narrow crescent wrapped around the softly glowing disk of the whole Moon. Beside it and just below was brilliant Venus, gibbous through a telescope, its gleaming white cloud-deck devoid of detail. Through light clouds a few degrees westward, yellowy Jupiter gleamed, its retinue of satellites and dusky banding a familiar sight through a small telescope. Just above Venus shone a light, a fainter light, inconspicuous beside the others — Saturn. Through a telescope, the tiny ball of the planet was circled by a ring touching nowhere and as bright as the planet itself.

A pretty sight in the predawn sky — four celestial bodies known since antiquity. But more than the pretty sight is the particularly stirring thought that two spacecraft are now speeding toward the faintest of those lights in the sky, one of them only weeks away from encounter. More striking still is the idea that each of these objects, these celestial bodies, has already been visited by spacecraft. The Moon has been walked on by twelve men, geological samples selected, chipped off, bagged, and carried back home to Earth.

Venus, at the moment we see it, is orbited by a spacecraft that has sent back tens of thousands of measurements, including radar photographs that penetrated its opaque clouds. Jupiter has played host to four spacecraft: the two pathfinder probes called Pioneer 10 and 11 and the two Voyager spacecraft — sophisticated reconnaissance robots now en route to Saturn. One probe, Pioneer 11, has already visited the ringed planet and returned a preliminary report. Now, with encounter only a week away, the first of the two Voyager craft is approaching Saturn.

Let's join that Voyager spacecraft about a week before encounter and fly with it on its journey past Saturn. As we approach the planet's vicinity, our Voyager begins to accelerate: to fall toward Saturn, gaining speed — only a few meters per second per hour at first, then faster and faster. The peak velocity as Voyager 1 whips under the planet's great bulk will be over 24 kilometers per second. Saturn, a week ahead, has grown slowly from a dot you could cover with your thumb at arm's length, to a disk your fist can't hide. The moons, tiny ball bearings, shuttle back and forth: little Mimas, completing its orbit in less than a day, Enceladus, Tethys, Dione, Rhea, all orbiting more majestically. Massive Titan, with a period of 16 days, lies half an orbit away on the far side of Saturn, and is moving around toward rendezvous with our craft on the near side.

Left: Two brown oval spots (right side) in Saturn's northern hemisphere each stretch some 10,000 kilometers across. This page: The dark, radial "spokes" in the rings were totally unexpected.



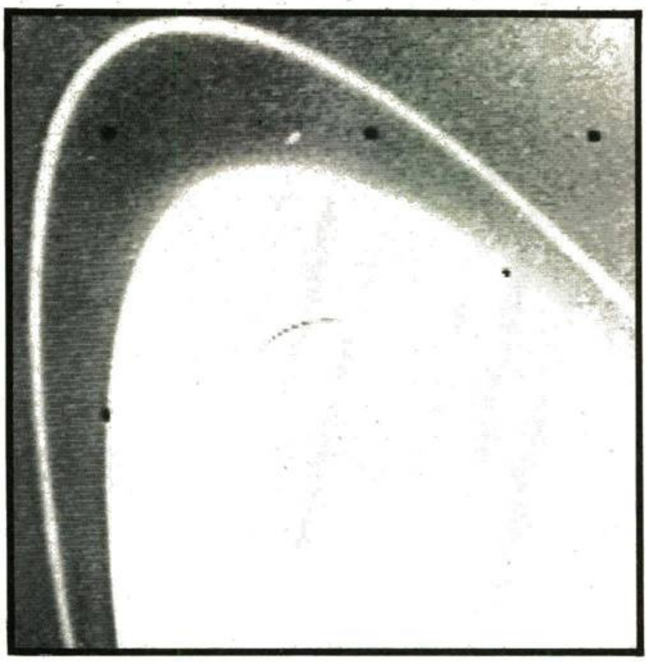
On Earth, the spacecraft controllers are preparing a final orbit correction: a short burst of gas, a tiny adjustment of velocity, to fly the spacecraft accurately down the planned pathway. There are tight constraints on that path if the mission is to function well. First, Voyager must pass directly behind Titan. Second, after the Saturn flyby, the time of emergence from behind the planet must be carefully controlled to minimize pointing errors in the important radio science experiment. Finally, for spacecraft safety, Voyager must exit through the plane of the rings exactly at the orbit of Dione to take advantage of that moon's "Safe Zone," a region where stray ring particles have been swept up.

Saturn grows in size, expanding day by day, filling, then spilling over, the narrow-angle camera's field of view. A golden ball, Saturn has delicate bandings of brown, grey, and tan — broad belts and zones of color. The southern hemisphere shows fewer features and the equator seems blander, less detailed, than the regions at higher latitudes.

The rings are lovely. We are seeing the sunlit side, the grand expanses of broad B ring, the gap called Cassini's Division at its outer edge, the breadth of the A ring, cut by Encke's Division. Inside the B ring, the C ring — fainter, semi-transparent — shows dark against Saturn's surface and bright against the black of space.

The spacecraft's powerful telephoto cameras reach out, shuttering again and again, recording the rings, the planet, the satellites — again, and again, and again.

On Earth, the pictures reveal details never seen before. The rings begin to break up into tens, then hundreds, of ringlets. The ringlets are narrow: 10, 20, 50 kilometers wide — structures unanticipated and



very difficult for the scientists to explain. The old theory that the rings are gravitational resonances with satellite orbits simply doesn't hold up with so many tiny ringlets to account for.

To the scientists, it's "data-shock." Color images, computer-enhanced, show up subtle differences between the rings. The C ring and the thin rings in Cassini's Division are bluer than the other rings — implying that they share similar materials or particle sizes. Cassini's Division, the dark "empty" line dividing the A ring from the B ring, under higher resolution turns out to have four broad sub-rings inside it — each some 500 kilometers wide — and one narrow ring, less than 100 kilometers wide. A day later, each of the sub-rings turns out to be filled with yet narrower structures.

The rings have still other surprises in store. The F ring, the thin ring outside the A ring, is flanked by two newly discovered satellites — S-13 and S-14. One orbits just inside the ring, the other just outside it. These two moons, it seems, play "sheepdog," as they "herd" the ring particles into line. Then as Voyager draws closer, the resolution of its cameras increases and the F ring appears to be clumped. At higher resolutions still, the F ring breaks into three braided components — twisting about each other. What causes the braiding? "I really don't know. It boggles the mind that it exists," says Bradford Smith, head of the imaging team.

The saturnian cloud tops appear bland compared to the vividly colored ones seen on Jupiter. Saturn, farther out in the solar system, is colder and its clouds, therefore, lie deeper in the atmosphere under a layer of haze. We peer in, trying to discern features, and as we fly closer with Voyager, we begin to see things: convection breaking up the overall flow, wave patterns, brown spots. One in particular draws our attention, a ruddy-orange oval cloud at mid-northern latitudes, about 6,000 kilometers long and 3,000 wide.

The science team is comparing Saturn with Jupiter. The low-contrast clouds were anticipated but the expected stable, even sluggish, atmosphere with broad zones and belts has not been seen. Saturn's equatorial jet makes Jupiter's seem tame: winds of 400 kilometers a second race around the planet. Saturn is alive with eddies that burst from below, swirl and dissipate their energy into atmospheric circulation. "These eddies don't live off the flow," says investigator Garry Hunt. "They drive it."

In the far infrared part of the spectrum, Saturn emits more of its own internal heat relative to the solar input than does Jupiter. Is this the residuum of primordial heat still escaping or is there some internal process, such as the separation of hydrogen from helium deep in the core, that's releasing energy? Why does Saturn have a simple, symmetric magnetic field while Jupiter has a complex and tilted one? Voyager will help provide those answers.

The cameras take frame after frame of Saturn and its rings; some of the longer exposures are in search of new satellites. The fugitive moon Janus, discovered with some difficulty by French and University of Arizona astronomers in ground-based observations, is picked up easily. Both moons, in fact, that lie in Janus' orbit are found! Temporarily named S-10 and S-11, the two tiny moons will become targets for high-resolution study at the time of closest approach.

The second satellite sharing Dione's orbit, S-12, is confirmed. New moons just inside and outside the F ring turn up. Named S-13 and S-14, they are both about 250 kilometers in diameter. A 15th satellite, just 100 kilometers across, orbits 800 kilometers outside the A ring. No smaller satellites are found.

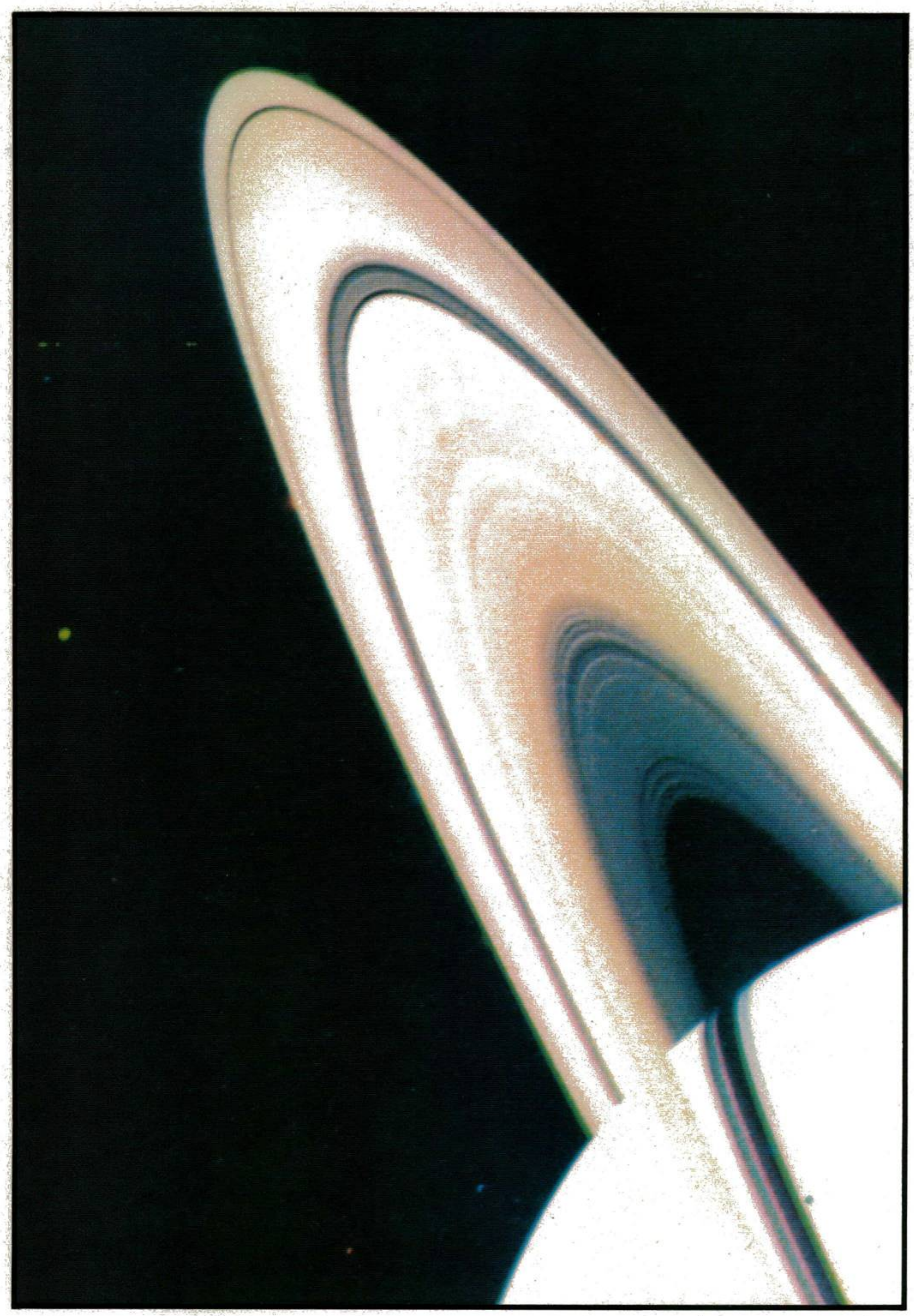
As Voyager approaches Saturn, it must pass from the unperturbed regions of interplanetary space, where the solar wind, the stream of atomic particles from the Sun, blows uninterrupted. The spacecraft's magnetic sensors and particle detectors monitor its languid surges across the long reaches of space — mostly protons, traveling outward from the Sun at some 400 kilometers per second. Saturn's magnetic field will not allow this charged wind to blow past unimpeded, but the pressure of this interplanetary wind warps the magnetic field backward and compresses it.

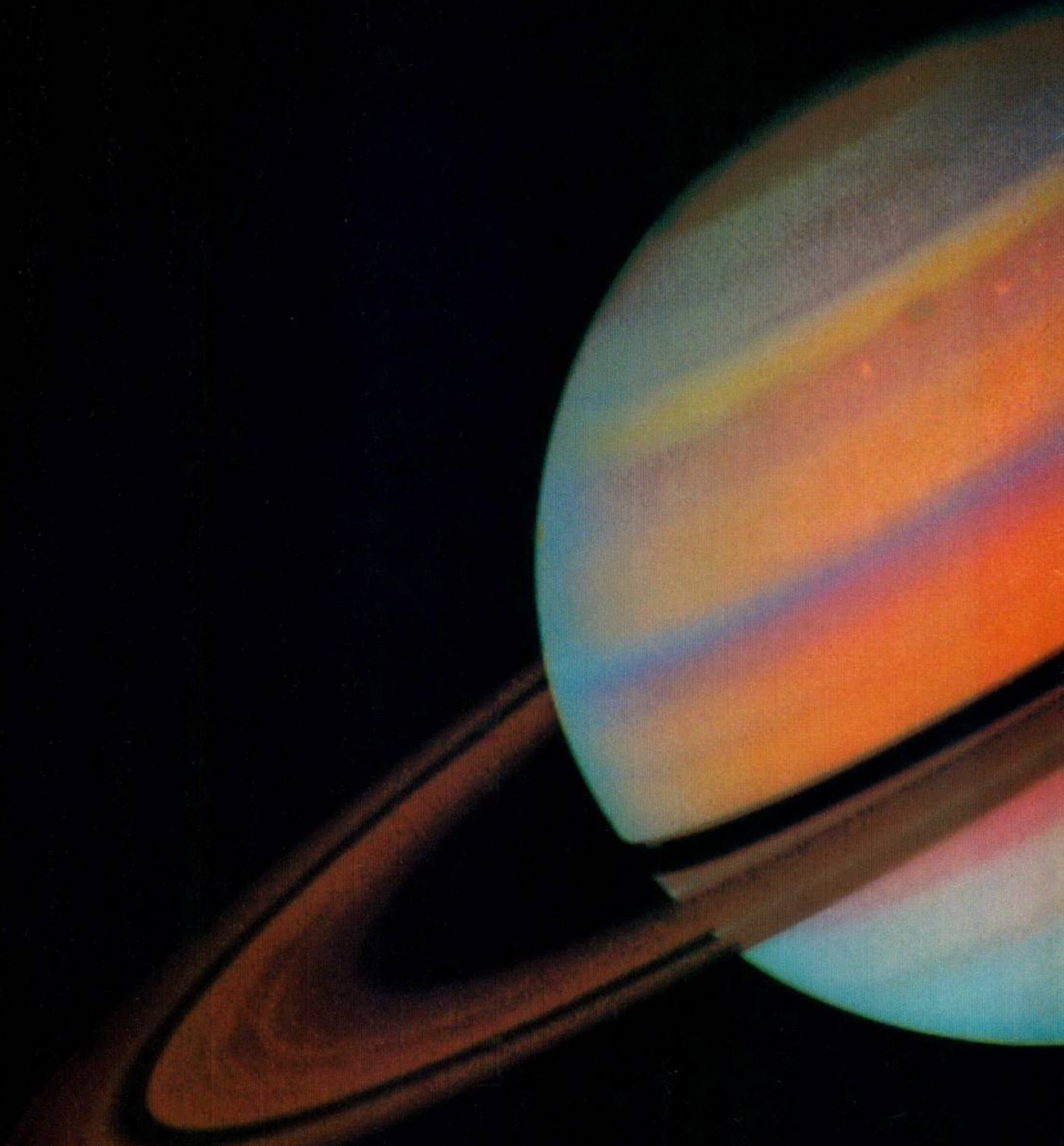
At the bow shock, 26 Saturn radii out, the solar wind first responds to the presence of the magnetic obstruction ahead. Voyager's sensors detect a sudden change beginning with violent turbulence and tangled magnetic fields. In this region the solar wind streams around Saturn's magnetic fields.

Voyager crosses this zone and flies through the magnetopause to enter Saturn's magnetic regime. In a matter of hours, Voyager crosses and recrosses this turbulent boundary layer five times. Then, at last, it finds calm. Here, protected from the vagaries and gusts of the solar wind, the spacecraft monitors ionized hydrogen and another ionized particle, one with 16 times the mass of hydrogen — perhaps oxygen or ionized methane. The scientists are pleased.

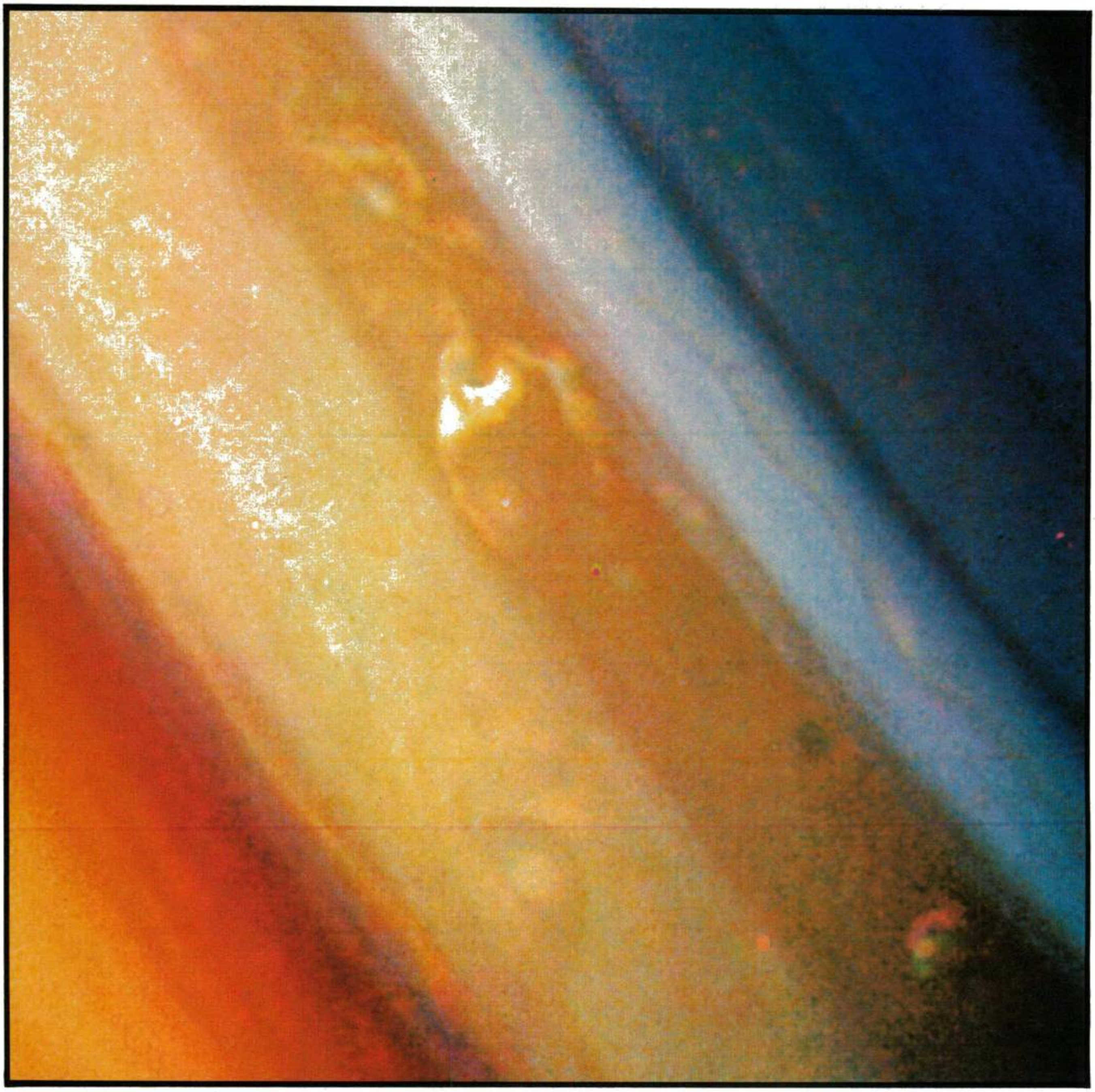
When Pioneer 11 flew into the saturnian

This page: Saturn's 15th moon (white dot at top center) orbits a scant 800 kilometers outside the A ring. Right: A color-stretched photo shows that Cassini's Division and the C ring are bluer than the A and B rings.





In this specially enhanced and computer-processed photo, the high thin atmospheric hazes that scatter ultraviolet sunlight show up with a strong blue tint.



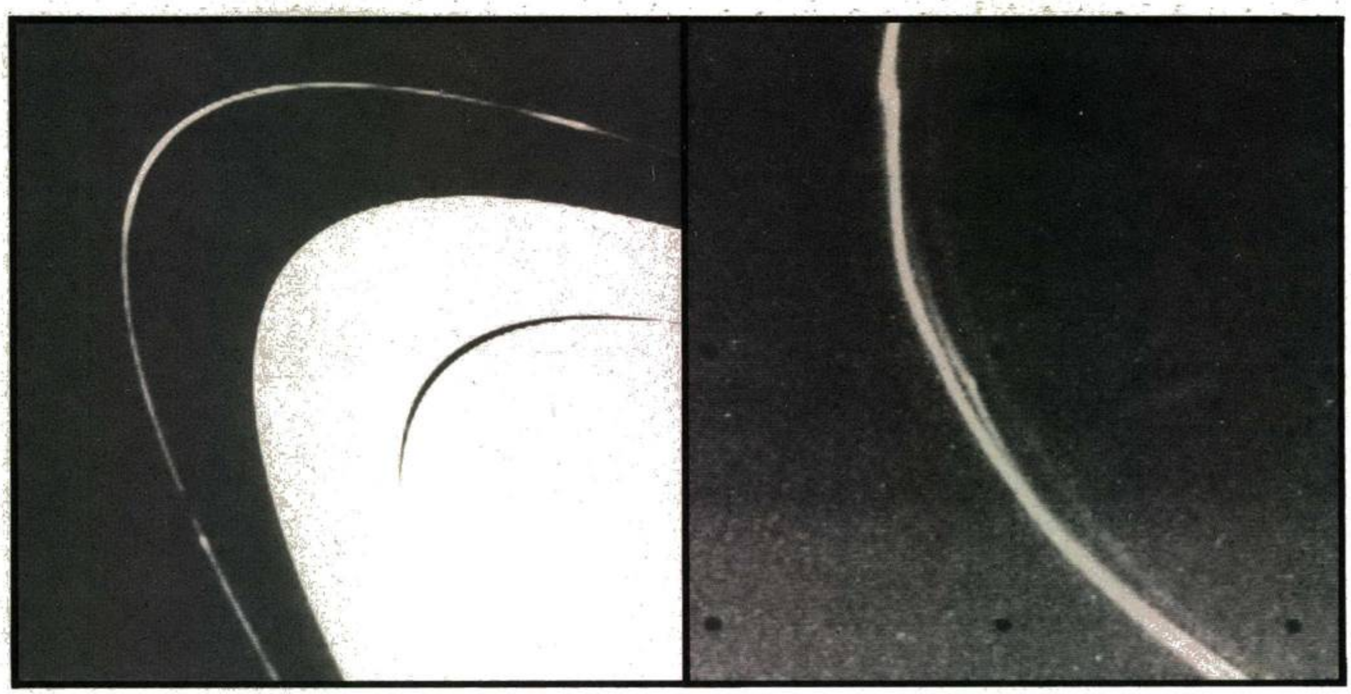
Convective clouds churn across Saturn's mid-northern latitudes in this computer-enhanced photo.

magnetosphere, it encountered the magnetopause inward from Titan. Titan then orbited in a region of magnetic confusion. When Voyager encountered the magnetopause, it was 200,000 kilometers outside Titan's orbit and Titan lay in a region of magnetic calm, well-suited for measuring its magnetic wake. As Voyager's closest approach with Titan nears, data stream in. Eighteen hours ahead lies the encounter with Saturn.

During the final day and a half before Saturn encounter, the attention of Voyager, as well as that of its ground controllers, is directed almost entirely toward Saturn's massive satellite Titan. In many ways, a Titan flyby is as important as a mission to Mercury or Venus. A major new world is being revealed.

The cameras run through their preprogrammed sequences: four pictures through three filters, again and again. At each mosaic picture, the Titan image grows larger as the spacecraft speeds toward rendezvous at 1,000 kilometers per minute: first, half the television frame, then two-thirds, then filling it. Soon it spills over to fill two frames, then three.

Titan looks like a vast, bland, orangy ball hanging in space. No detail is visible on its surface. Indeed, its surface still lies hidden and we see only featureless cloud top. As we move closer, subtle shadings appear: a darkening over the northern polar regions, a thin high haze engulfing the entire planet hundreds of kilometers above the solid cloud deck. Another perplexing feature to be explained: the entire northern hemisphere is slightly darker than the southern hemisphere.



The narrow F ring, discovered by Pioneer 11, had further surprises for scientists: varying brightness (above left) and a twisted, braided structure (above right).

The scientists are working furiously to understand the bland globe. Of the many possible models, two are preferred, and the scientists eagerly anticipate the radio occultation measurements that would pin down a vital titanian figure: its diameter. Because of Titan's great distance from Earth and its obscuring atmosphere, the diameter of its hard surface has never been accurately determined. This has left the density of Titan unknown, bracketed somewhere, almost anywhere, between the densities of ice and rock. Earth-based polarimetric observations a decade earlier had shown the Titan surface was covered by clouds or haze. Now, at last, the scientists are seeing, and being frustrated by, that haze: Voyager sees no surface.

In the final hours some structure emerges in the haze layer. Wrapping around the sunlit limb, we see a high thin haze, and over the north pole this darkening resolves itself into a beanie-like cap.

As Voyager flies closer still, the cameras begin a high-resolution sequence — pictures that might have shown tiny craters, mountains, and valleys, if there were details to see. But nothing shows, only orangy haze.

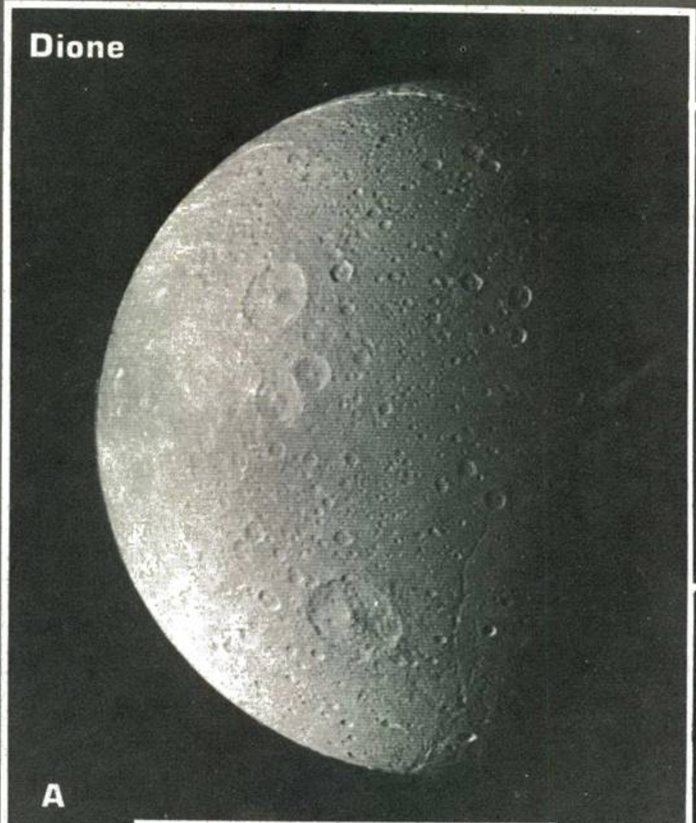
We now rapidly approach Titan occultation — the brief instant when the spacecraft will pass directly behind Titan. Several important experiments involving the radio transmitters will beam their signals through the cloud layers, revealing many now-hidden facts: the diameter of the solid surface of Titan, the pressure at the bottom of its atmosphere, the temperature of the cloud tops ("although the surface temperature would have been preferred"), the composition of the atmosphere, and the effects of a possible titanian magnetic field.

Titan looms large, filling the sky and illuminating the spacecraft with its jaundiced glow — then we plunge into Titan's shadow. The spacecraft transmits a steady signal back toward Earth, one and a half billion kilometers away, an active radio probe of Titan's secrets.

On Earth, spacecraft controllers are nervous. At Madrid, one station in the Deep Space Network of receivers has had weather problems for days. Heavy rain and thunderstorms have already blotted out some of Voyager's transmissions. Will it rain? Will the critical Titan data be lost? Rain it does, beginning five minutes before Titan encounter and ending twenty minutes after! Luckily though, no data is lost — in fact, it's all good data. The scientists are again pleased.

After Titan we turn our attention to the planet, now looming over the spacecraft, its magnificent rings stretching across the sky, the ball of the planet overfilling a human's comprehension. And to the inner satellites — Rhea, Dione, Tethys, Enceladus, Mimas, and the tiny pair S-10 and S-11. Titan marks the point of ring plane crossing as Voyager dips from the northern side, where the Sun illuminates the rings, to the eerie reversed contrast of the backlit southern side. We look at the spectacle above our heads — outermost, the thin F ring shines bright, then a dark gap to the outer edge of the A ring, a shimmering arc of many ringlets. Cassini's Division, dark from the sunlit side, glows bright when backlit. The B ring is almost opaque, a thin glimpse of white shines between its ringlets. The C ring, tenuous from the front, glows brightly from the backlit side. In a brief 22 hours, Voyager dives below the ring plane, swings past Saturn, grabs hundreds of pictures of the rings, the planet and its satellites, and swings back, right on target through the Dione "Safe Zone," and away from near encounter. Nothing hits Voyager at either ring plane crossing. The spacecraft has survived.

Of the satellites, first S-10 and S-11, then Tethys, Mimas, Enceladus, and Dione, swell before the cameras and recede again. Photographs record their surfaces with resolutions at just a few kilometers. It is truly an exciting time.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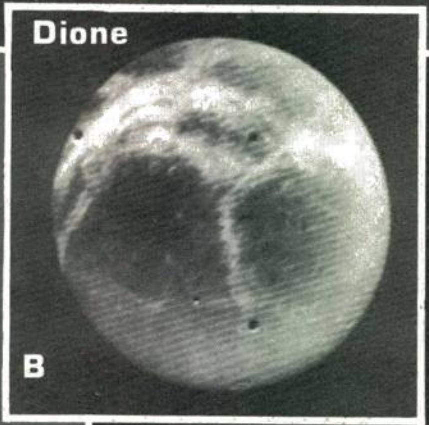
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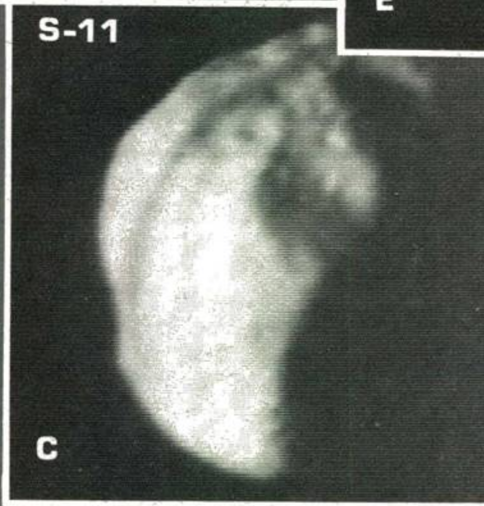
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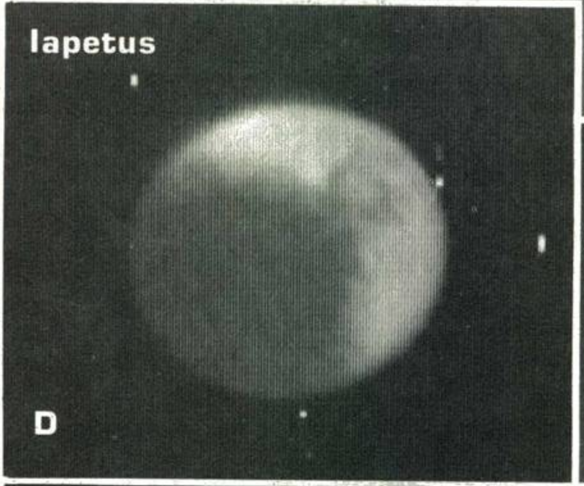
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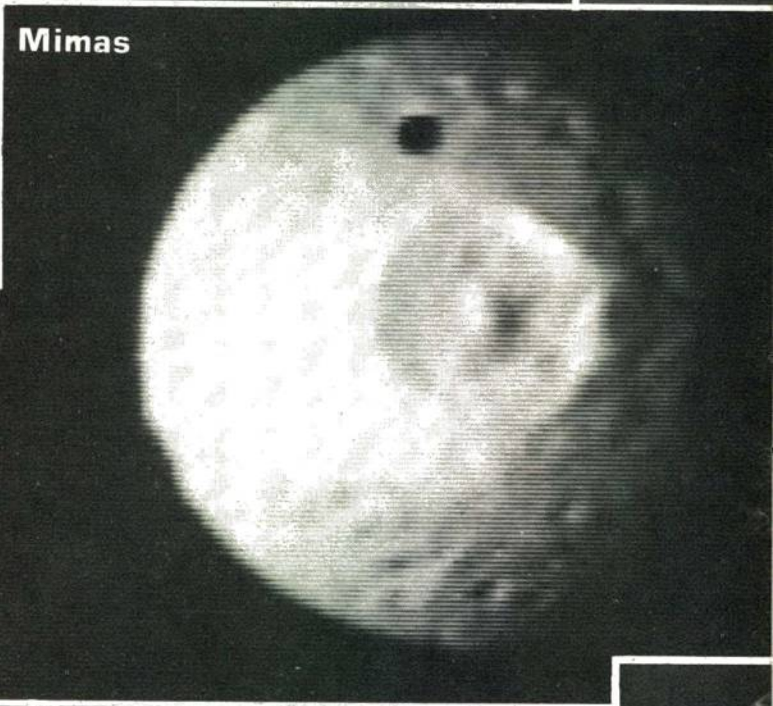
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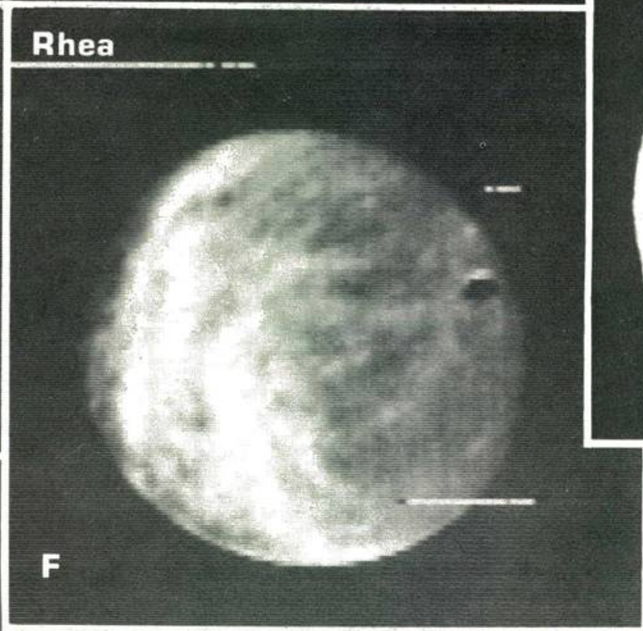
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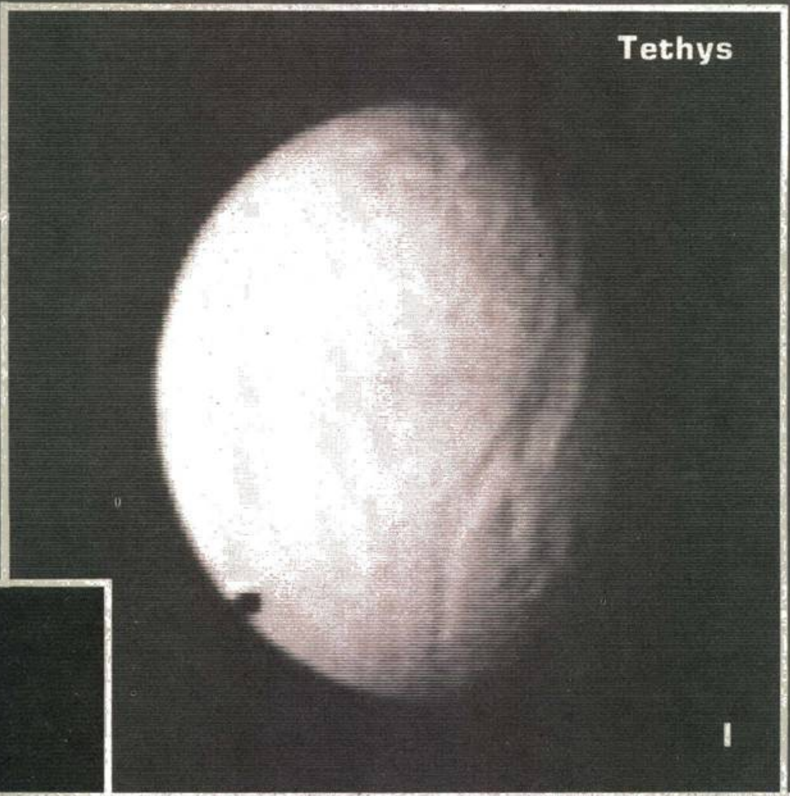
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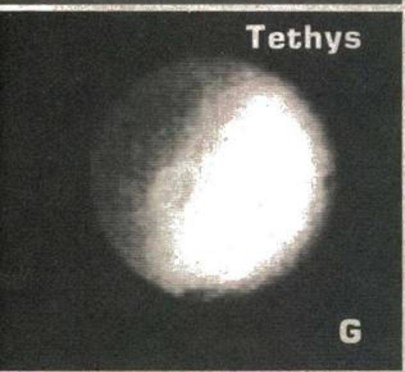
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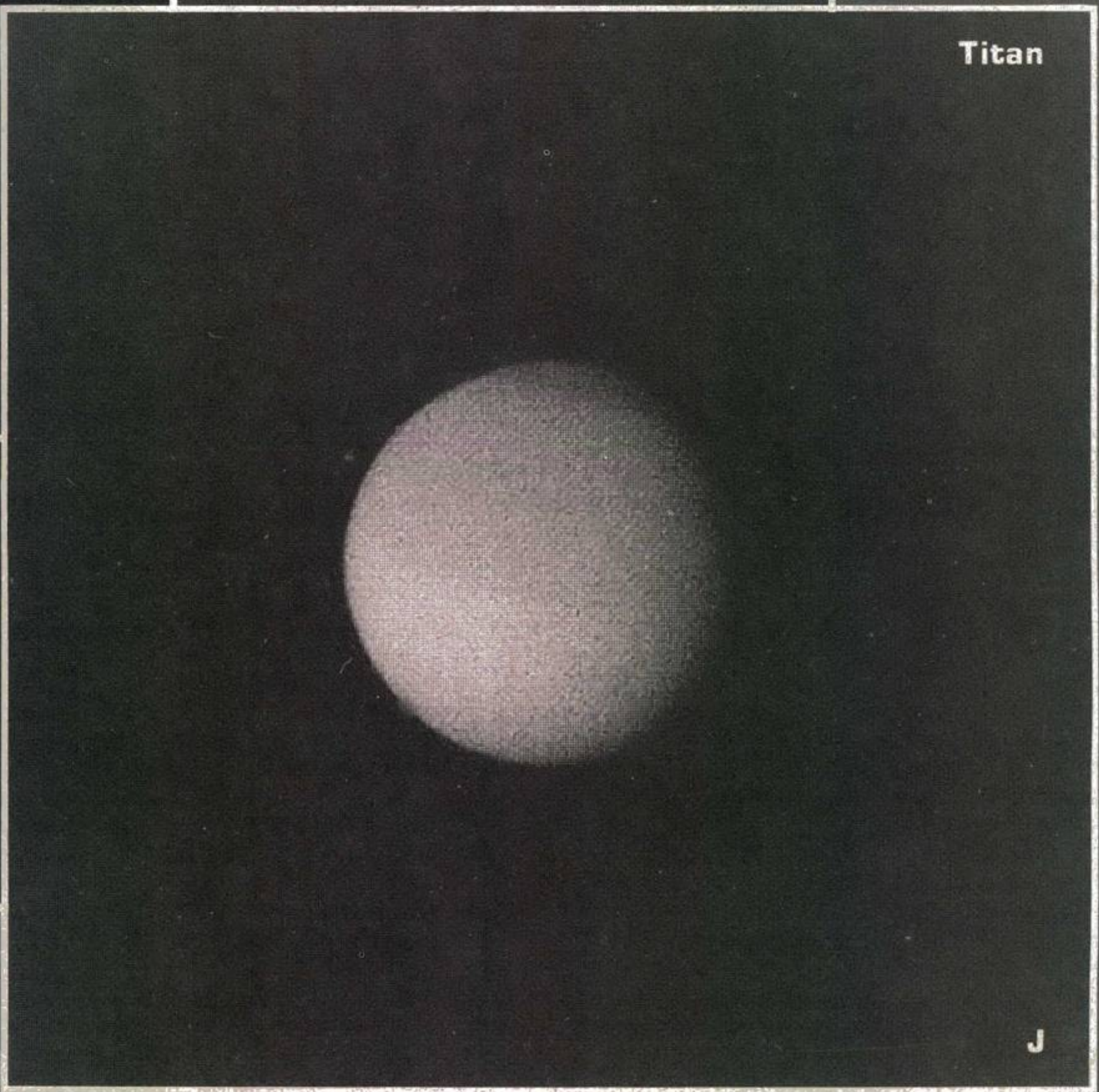

Titan
J

Working together, scientists on the imaging team, the ultraviolet crew, the infrared group, and radio scientists quickly piece together a picture of Titan. The methane, long known to be present from Earth-based data, is detected in the infrared. But the ultraviolet experiments find nitrogen (impossible to detect through Earth's atmosphere) high above the limb. The radio team provides a preliminary determination that the surface pressure of Titan will be high — at least a time and a half that of Earth. Atmospheric scientists pitch in with model atmospheres and the Titan atmosphere emerges as a mixture of methane — but probably only about 1% — and nitrogen, about 99%. The clouds are cold, likely clouds of liquid nitrogen droplets, just like Earth's clouds of water droplets.

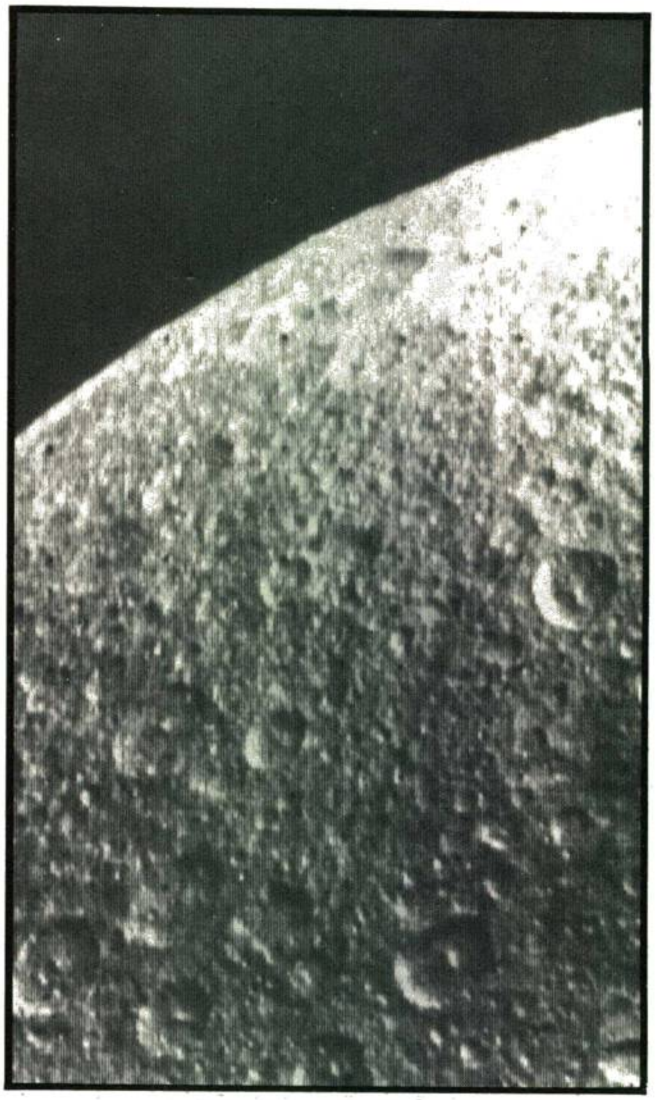
The high altitude hazes are produced by ultraviolet sunlight working to break up methane. Some hydrogen escapes and a hydrocarbon residue settles down toward the surface. In another simultaneous process, sunlight acts on nitrogen and methane to form hydrogen cyanide. This accumulates and diffuses down to the lower atmosphere in a mixture of about three molecules hydrogen cyanide to ten million nitrogen — about a third of a lethal dose for humans.

Voyager 1 Saturn Photo Data

For each picture shown on these pages, this table gives the date taken and the distance between the Voyager spacecraft and the subject of the picture. The picture number is NASA's designation and specifies the image uniquely in their files.

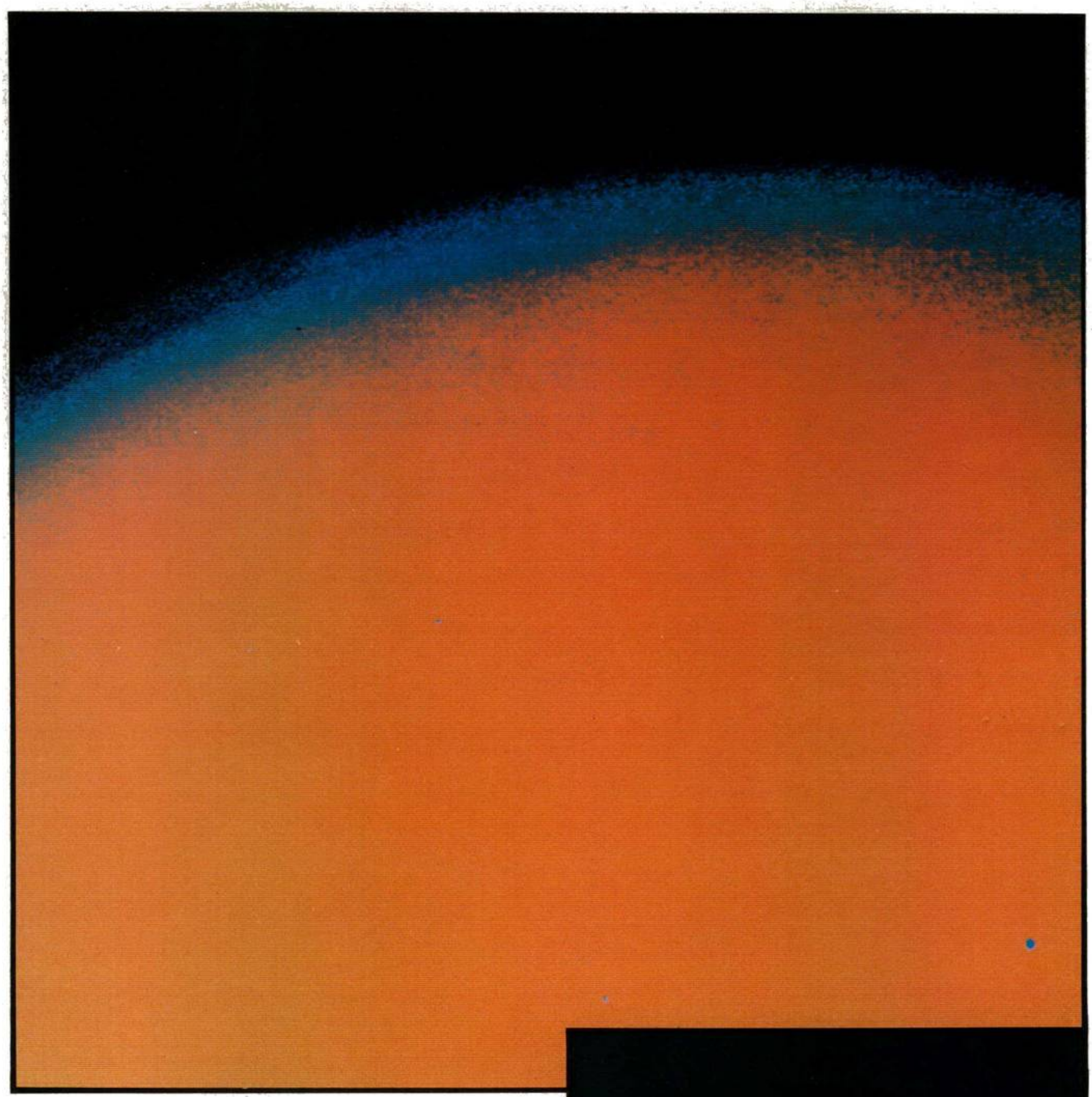
Page	Date	Range (kilometers)	Picture #
Cover	Nov. 3	13,000,000	P-23058
4-5	Nov. 10	3,500,000	P-23097
6-7	Oct. 30	18,000,000	P-23077
8	Nov. 7	7,400,000	P-23073
9	Oct. 25	24,000,000	P-23053
10	Nov. 7	8,000,000	P-23070
11	Oct. 30	18,000,000	P-23074
12-13	Oct. 18	34,000,000	P-22994
14	Nov. 5	8,900,000	P-23062
15 (left)	Nov. 8	6,400,000	260-958
15 (right)	Nov. 11	760,000	P-23099
16 A	Nov. 12	162,000	P-23113
16 B	Nov. 12	790,000	P-23094
16 C	Nov. 12	177,000	P-23104
16 D	Nov. 12	3,200,000	P-23105
16 E	Nov. 12	660,000	P-23098
16 F	Nov. 11	1,925,000	P-23085
17 G	Nov. 11	2,000,000	P-23084
17 H	Nov. 12	129,000	P-23112
17 I	Nov. 12	1,200,000	P-23095
17 J	Nov. 9	4,500,000	P-23076
18	Nov. 12	72,000	P-23102
19 (top)	Nov. 12	430,000	P-23108
19 (bottom)	Nov. 9	4,500,000	P-23076
20	Nov. 11	1,176,000	260-989
21	Nov. 12	162,000	P-23113
22	Nov. 13	1,500,000	P-23178

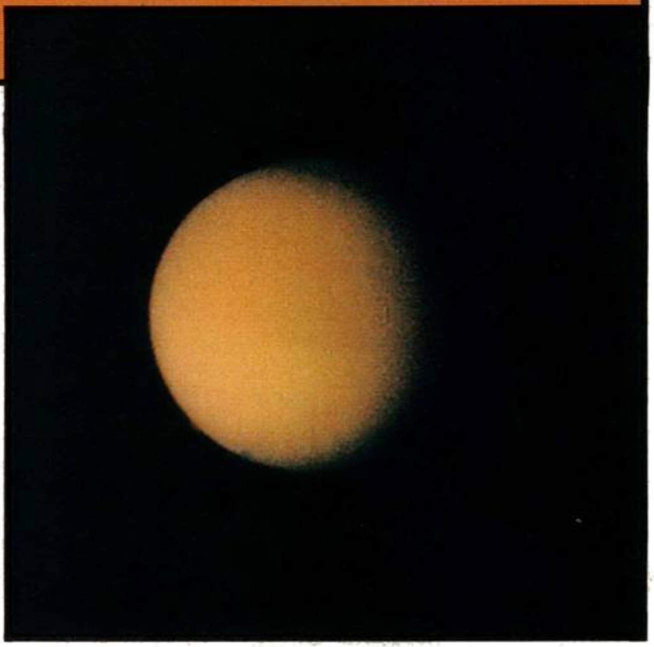
Richard Berry, ASTRONOMY's Editor, covered the historic Voyager 1 flyby of Saturn during ten days and nights at the JPL pressroom. JPL manages and controls Project Voyager for NASA's Office of Space Science. All photographs in this article are courtesy of JPL and NASA. The author wishes to express his thanks to the JPL Office of Public Information for their help and cooperation.



Fresh-looking craters with sharp rims alternate with battered ancient ones across the landscape of Rhea. The central peak found in most comes from elastic rebounding of the surface materials at the time of impact.

When Voyager flies through closest approach, it passes behind Saturn and the ring system. This is a time for another critical radio science experiment, one in which the radio beam from Voyager shines through the atmosphere of Saturn as it passes behind the planet, and again when it emerges. As Voyager glides behind the rings, the radio beam probes particles of the rings for twenty minutes. Then, rising above the ring plane, Voyager points its antenna down at the rings and transmits a signal toward them. The ring particles scatter the energy in ways that depend on their size, composition, and number. One and half billion kilometers away, the sensitive receivers of NASA's Deep Space Network measure the signals, and the scientists begin the tedious and tricky job of interpreting the results.

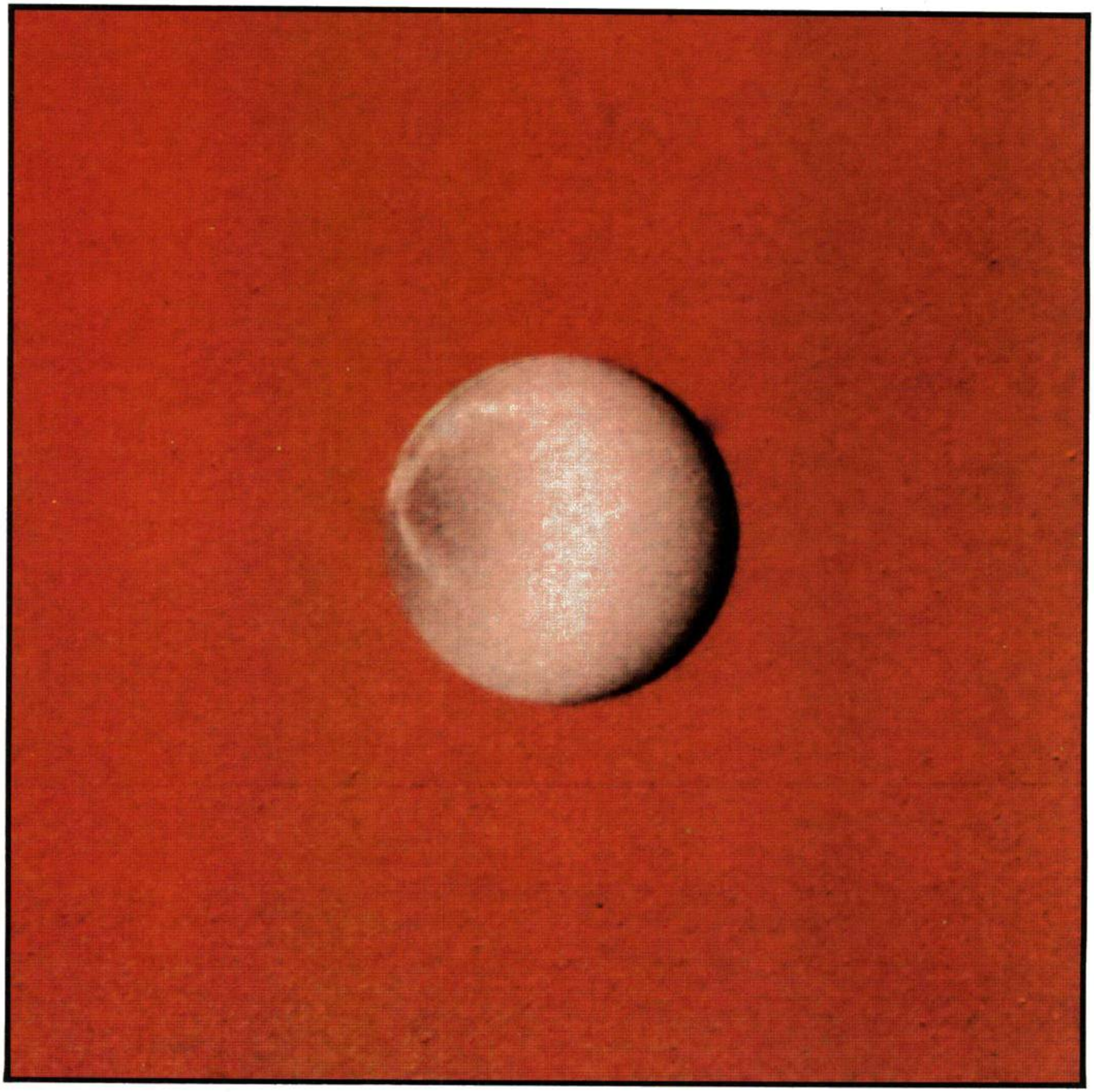




Above: A bluish haze merges into a polar cloud hood at Titan's north pole. Right: The enigma of Titan's surface lies well-hidden below its opaque orange clouds.

Trying to understand the features shown on the saturnian satellites almost the minute they return, makes the scientists nervous. There is no time for the standard diagnostic tools of planetary science — crater counts, measurements of size, slope, age, reflectivity, density. Nevertheless, there is much to see. With the exception of Titan, all of the satellites are 50/50 mixtures of ice and rock with bright icy surfaces. All but Titan are a new class of celestial bodies we haven't seen before: bodies 1/10 to 1/100 the mass of the Galilean satellites.

Mimas displays a huge crater on its Saturn-facing side. Craters saturate its other side, with a few large



Above: Dione in transit across the face of Saturn. Right: The leading hemisphere of Dione is heavily cratered — in contrast to the trailing hemisphere's wispy bright streaks.

trenches among them.

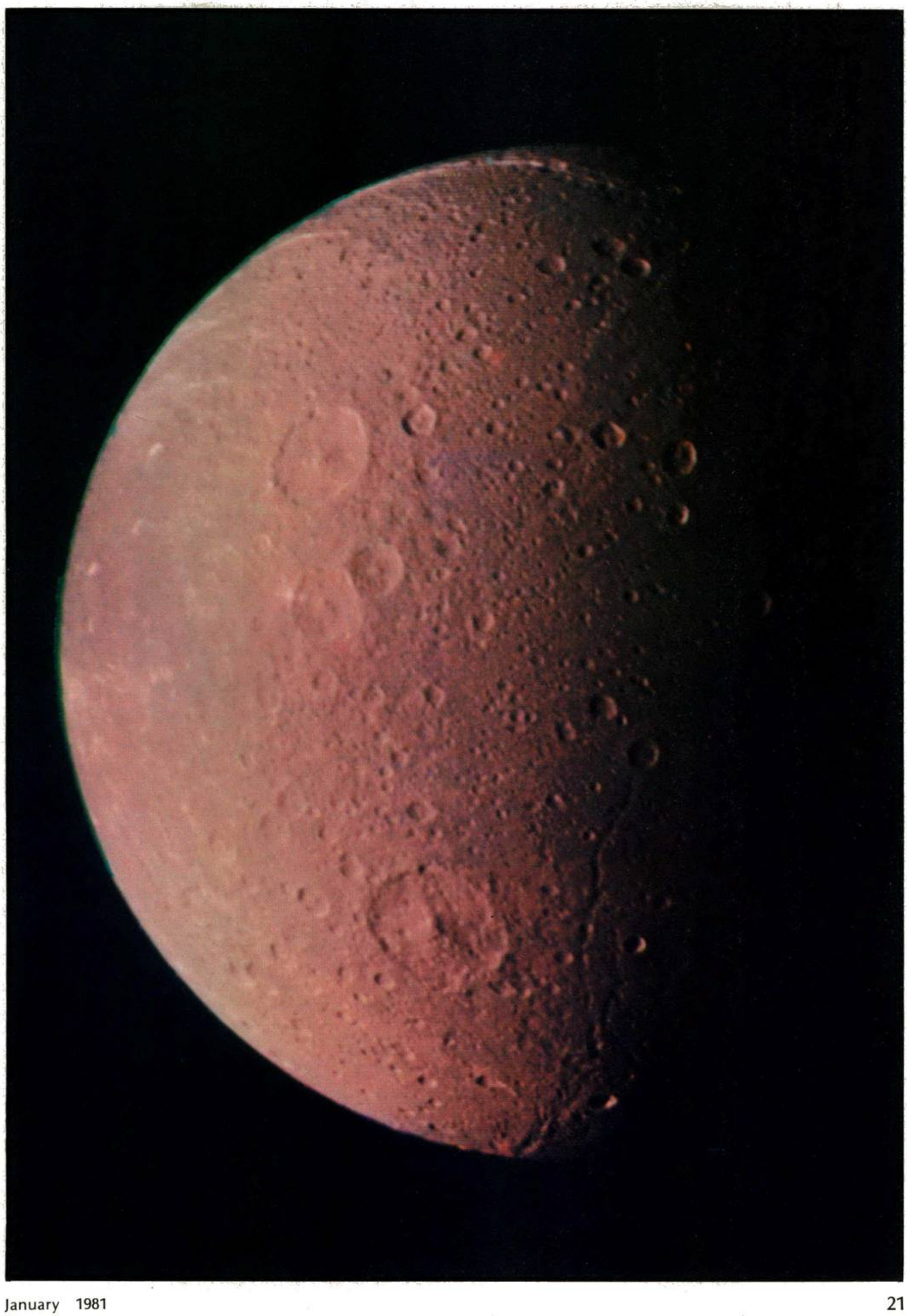
Tethys is heavily cratered all over. Strange bright markings dominate the face not well seen by Voyager. On the other side are a number of giant grooves.

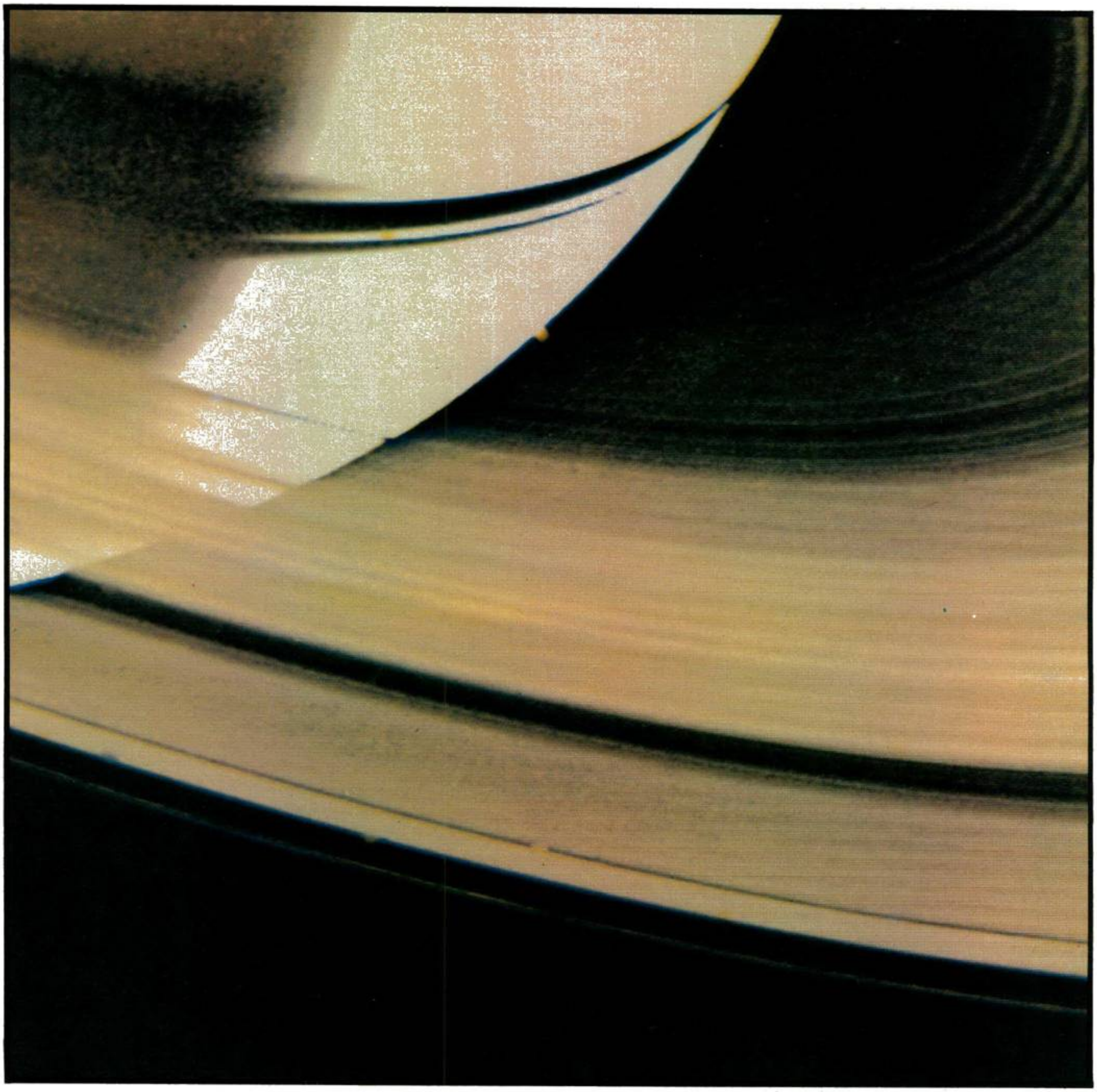
Dione displays bright wispy features which seem to be painted on the surface, so little is their relief. At the very center of the wispy structure lies a large and very battered impact basin. The bright wispy features are *not* crater rays, *not* grooved terrain like Ganymede, but possibly outgassing products — frost, maybe snow — emanating from a cracked satellite surface. Directly opposite the basin is a curiously smooth region with far fewer craters than other parts of the globe.

Rhea is another heavily cratered body. Crater debris piles on crater debris, until each new crater destroys as much as it creates. Rhea looks like Mercury and the Moon, but it's made of bright, highly reflective ices. Its craters are different — not as round, but more ragged — products of a cratering process even less dominated by gravity than lunar craters.

Interest in Iapetus is dominated by its strange dark leading side — a side covered by some material as black as coal. The trailing surface is much brighter. Iapetus has at least one giant crater, but the resolution of the TV cameras is not sufficient to show much more.

Enceladus is much different. It has very few craters and just a few crack-like features visible at Voyager 1's camera resolution. (Voyager 2 will obtain better pictures.) What can explain Enceladus? It lies in





Past closest approach and on its journey outbound, Voyager looked back and down upon the rings.

a two to one orbital resonance with Dione, which may raise tides and heat its interior, melting or softening the icy materials that make up the satellite.

All of these moons probably date back to the beginning of the solar system. Their craters reflect the birth pangs of formation and the final stages of accretion. Their outer surfaces are icy rubble, and the rock that makes up 50% of their mass must lie deep inside, perhaps tucked into a rocky core. Ice as cold as the saturnian satellites has a hardness like rock; only Europa-like Enceladus appears to have ever heated or softened.

As Voyager leaves, it continues to return data: pictures of the unlit back of Saturn, infrared and ultraviolet scans of its dark side. More: searches for aurorae and more moons, magnetic fields data, charged particles, and radio waves. We look back and see a shiny crescent wrapped in its rings. From Voyager's vantage point, now high above the rings, even the B ring appears transparent, its light the result of billions and billions of tiny saturnian satellites. We see hints of the B ring extending inward toward the planet and the C ring. We see the F ring clearly. We see the dark side glowing by light reflected from the rings. We see Saturn's moons as narrow crescents.

We relax with Voyager — we're on our way out of the solar system.

In the next issue of ASTRONOMY we will report in much more detail the scientific results that have come from the Voyager 1 flyby of Saturn.

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ASTRONOMY FORUM

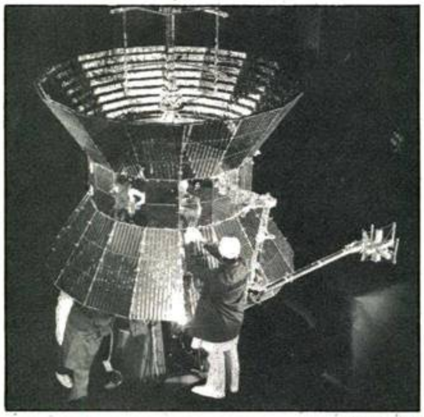
The Future of Space Astronomy

In the three and a half decades since World War II, astronomers have arrived at a totally new view of the universe. No longer do they have a picture of a poetic and serene cosmos populated by beautiful wheeling galaxies. They now have a view of an astonishingly violent universe — a universe created from a hot, dense fireball and inhabited by variable quasars, exploding galaxies, X-ray spewing neutron stars, and black holes.

Arising from this new view are some vexing questions. For example, is the universe, which now seems to be expanding, going to expand forever, or will it start collapsing one day and return to its primordial state? What is the role of interstellar organic molecules in the evolution of stars and planets and, indeed, of life on the Earth? And what are the mechanisms that produce so much energy in supernova explosions and galactic nuclei? Astronomical research performed in space (known as space astronomy) has helped to clarify these questions and brought them to the forefront of astronomy today.

But, as I will argue, the future of space astronomy depends not only on the existence of exciting problems awaiting solution by space techniques. It also depends on the important trans-scientific factor of political and financial support. Because this support was present in the late 1950s and 1960s, research in space astronomy flourished. Scientists had frequent opportunities to place experiments above the atmosphere. In the 1970s, however, the political temper toward space investigations cooled, resulting in cutbacks and cancellations of missions already planned. Will space astronomy in the 1980s be more like the golden 60s or the gloomy 70s?

Astronomical investigations from outer space are recent. Only since technology became sophisticated enough to permit sending instruments above the atmosphere and pointing them toward astronomical sources have such investigations been possible. The concept of space astronomy, though, is not so new. Early in this century, people such as rocket engineer Hermann Norduung realized that it would be advantageous to astronomers to place a telescope into a high Earth orbit. There, the problems associated with looking through the atmosphere would not exist. These problems included such obvious things as clouds and other weather-related obstructions, as well as the distortion of stellar light due to dust, pollution, and the thermal motion of the air. Above the clouds, an astronomer could look into distant space with remarkable clarity.


ESA/NASA

When space vehicles were first made available for scientific use in the late 1940s, however, they opened new windows in the electromagnetic spectrum. The atmosphere makes some observations impossible. Water vapor, ozone, and ions in the upper strata absorb radiation from almost all parts of the spectrum with the exception of optical and some radio wavelengths. Until World War II, and before the advent of radio astronomy, all knowledge of the universe was therefore gained through the optical "window." But by placing instruments in space, scientists could study radiation from the entire spectrum and either confirm, expand upon, or alter the view of the cosmos obtained by optical methods alone.

Aware of the potentials of space investigations, a number of scientists at the Naval Research Laboratory in Washington, DC grasped the opportunity. Using converted German V-2 rockets, they made observations of the Sun in the previously unexplored ultraviolet and X-ray regions of the spectrum. Their investigations also marked the beginnings of observational space astronomy, albeit on a very limited scale.

The Sun was the logical choice for the first object of study by space astronomers. Bright, and close to the Earth, it affects terrestrial weather and international radio communications. But in the late 1950s, the NRL physicist Herbert Friedman and his colleagues developed techniques that permitted the use of instruments on short-lived rockets for studying faint nonsolar objects, especially in ultraviolet wavelengths. During the 1960s and 70s, further rockets and then satellites carrying ultraviolet *detectors were launched, leading to* discoveries of, among other things, dense gas clouds in the interstellar medium and hot mass ejected from

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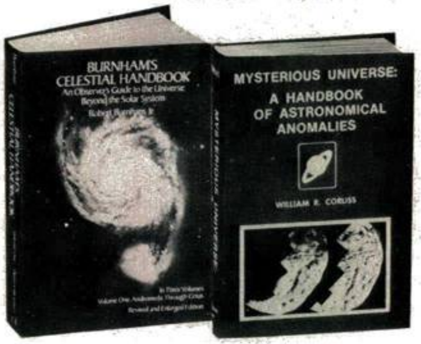
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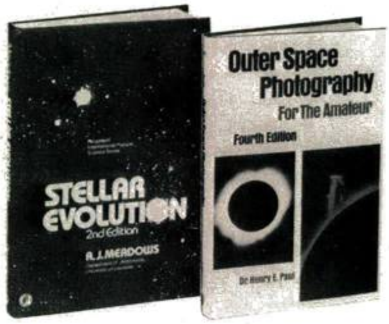

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rapidly evolving stars.

After the space race got under way in 1957, scientists considered the possibilities of exploring still more exotic parts of the spectrum. The very high energy gamma ray region of the spectrum appeared in theory to be extremely promising, but early experiments indicated that the radiation (which is produced by nuclear de-excitation) was feeble and difficult to detect. It was only after about 10 years of searching that the first discrete gamma ray source was discovered.

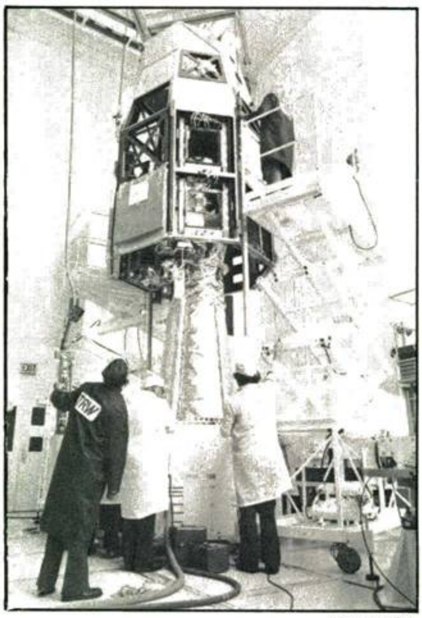
In the meantime, the X-ray window, which in theory appeared even less favorable than the gamma ray window, proved to be extremely exciting to look through. In 1962, Riccardo Giacconi and colleagues at a small scientific company discovered the first unexpectedly bright X-ray source (over 100 million times as intense in X-radiation than the Sun). Within a decade, over 100 similarly bright emitters were detected. Some turned out to be exotic objects, such as spinning neutron stars, and another a possible black hole. In a less dramatic fashion, the infrared window has also been opened in recent years. Unlike X-rays coming from space, which provide information concerning the final stages of a star's evolution, the infrared rays tell us about the cool early life of a star, as dust and gas coalesce to form the nucleus of a stellar object. Taken together, the opening of these new windows into space constitutes one of the most significant changes in postwar astronomy.

The great advances made in space astronomy were made possible partly because of a commitment by the United States government to fund scientific research. Reflecting a new attitude in public policy developed during World War II, government support has been offered on the premise that basic research provided a store of knowledge that could be drawn upon in national emergencies. In the immediate post-war years, nuclear and atomic physics were the primary beneficiaries of this policy, but astronomers working with ground-based instruments also benefited through the largesse of the military services and the National Science Foundation.

After the Russians launched Sputnik in October 1957, however, this situation changed dramatically. Orbiting the Earth at an inclined angle so that it could be seen by practically the entire world, the satellite signaled to many that America's domination in science and technology (two fields that reflected her military strength) was over. Within days of the launching, America's international prestige had plummeted. People were talking about the "Pearl Harbor of the Technological War."

Also within days, American political leaders began seeking means of recapturing their country's lead in science and technology. In addition to authorizing new funds for scientific education, Congress and President Eisenhower took steps to increase funding for those military agencies that had already performed space research in a modest way since the end of World War II. Congress also created a new civilian agency — the National Aeronautics and Space Administration — whose primary mission consisted of the exploration of space. In the early days of the revamped space programs, the government encouraged the development of new fields of space research that would capture the public interest. One early success was the discovery of radiation regions around the Earth, since known eponymously as the Van Allen radiation belts.

By 1962, however, political imperatives called for a shift in the complexion of the civilian space program. This came about as the United States suffered a second major setback in the space race a year earlier — in April 1961 — when a Russian cosmonaut became the first man in space. Reeling also from the Bay of Pigs disaster occurring shortly after the Russian success, President Kennedy announced, in May 1961, a dramatic acceleration of the manned space program which had previously been only a small part of the NASA mission. In the agency's enabling legislation, for example, such a program ranked as a third priority, while scientific exploration of space ranked first. Nevertheless, political events impelled Kennedy to have NASA redirect its efforts. Concurring with the President, Congress recommitted itself to the space program. NASA's appropriations were boosted from $330 million in 1959 to over $5 billion in 1965 and 1966. While overshadowed by the manned lunar program, space astronomy did not suffer in this new phase of its relationship with public policy. Funding for astronomy increased by a factor of about six. Money was provided without much hesitation to all space programs. Space astronomy rode piggyback on the manned program; when funding was good for the lunar mission, it was also good for basic research.


TRW/NASA

The support came at a fortuitous time for space astronomers, and especially for those in fields such as X-ray astronomy. Discoveries of unusual and cosmologically significant sources were increasing and more sophisticated research technology was needed. Almost invariably, the cost of the experimental tools rose continously throughout the decade. The pioneering activities had been relatively cheap. The first rocket-borne experiments required an expenditure of about $200,000. By 1970, the cost of constructing and launching the first X-ray satellite amounted to $37 million. The general trend in space astronomy was — as it has been in many other rapidly evolving fields of science — that major conceptual advances became steadily more expensive.

During the heady years of the 1960s, the increasing costs were absorbed as part of a civilian space program that enjoyed presidential, congressional, and popular support. After 1969, when American astronauts had successfully landed on the Moon, much of the support dissipated as Congress concluded that NASA no longer had a mission and therefore did not deserve such generous funding. Influencing these cutbacks were the drain on the federal budget due to the Vietnam War and popular disillusionment with science and technology, which was being widely blamed for environmental and social problems.

The next phase of public funding for space astronomy was therefore characterized by decreased support. In 1965, at the peak, space investigators received $160 million.

Nine years later, the appropriations dropped to $64 million. During the Carter administration, support has increased to a new high of $285 million in 1979, but due to inflation, the new funding level still does not provide the same number of opportunities for space research as the money did in 1965.

This funding history has caused serious problems for the community of space astronomers. Since the 1950s, a number of new subdisciplines have emerged and gained large research communities. In the 1970s, they were forced to compete against each other for a part of the decreasing size of the NASA pie. As priorities had to be reshuffled, previously planned missions have been canceled, pared down, or delayed until money could be found.

To get an idea of how serious these cutbacks have been, it is instructive to look at a long-range program in space astronomy that was devised by NASA's Astronomy Missions Board in July 1969. In its minimum program (a program defined as one that would proceed at the minimum rate necessary to attract and retain the interest of the leading workers in the field), the Board envisioned an annual expenditure of 250 million constant dollars through the mid-1970s. If one computes the effect of inflation, this minimum amount has not yet been available to astronomers. The Board suggested the launch of four large satellites by the mid-70s for research in gamma ray, X-ray, and cosmic ray astronomy. On one of these satellites there was to be a large telescope for producing images of X-ray sources. The reality of the 70s, however, consisted of the launch of only three vehicles, each one-third the size originally planned, with the X-ray telescope only half its expected dimensions. And in optical and ultraviolet astronomy, the goal for the mid-70s was to place a 1-meter aperture telescope into space and a 3-meter telescope into space by the early 1980s. Neither of these goals has been accomplished. Current plans call for launching the smaller telescope onboard the Space Shuttle's second Space-Lab. Due to problems with the Shuttle, however, it is unlikely that this smaller instrument will make its first observations until 1983 or 1984. Meanwhile, the 3-meter Large Space Telescope may never get into space. The instrument has been plagued by fiscal problems and is now planned as a smaller 2.4-meter Space Telescope that may make it into space in the middle to late 1980s. In

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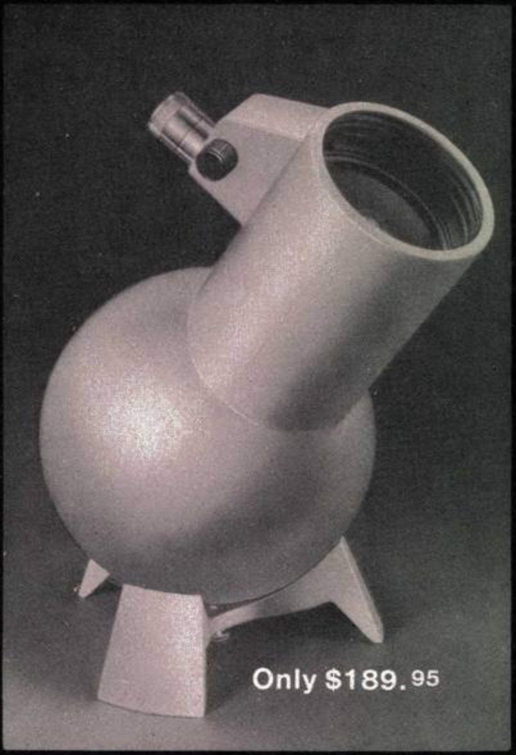

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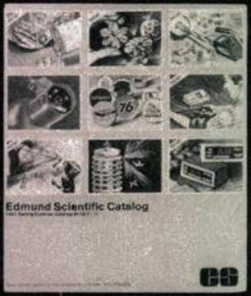

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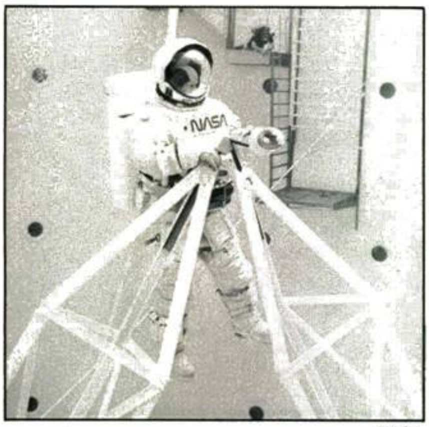
a similar fashion, many other programs for infrared and radio astronomy that were planned for the minimum program of the 1970s have not yet gotten off the ground.

Before I present my predictions for the future of space astronomy, let me recall a prediction made in 1950 by the noted radio astronomer, Sir Martin Ryle. After witnessing the launch of the first space astronomy experiments, he argued:

"Whilst some important results are likely to be obtained by the development of further rocket-borne apparatus, it seems unlikely that such brief and expensive experiments will play a major part in the growth of observational astronomy."

All predictions are, by their nature, precarious. But it indicates that Ryle was unaware of the importance of political support for space research. Such support was crucial for the development of post-war astronomy, and it is likely to be important in the future. Between 1957 and 1969, the political need for the space mission to counteract the spectacular technological triumphs of the Russians was great, and space astronomers received incentives to be productive. Since 1969, without the perceived pressure of foreign competition, the space program has failed to garner political support. In general, as George Mueller, president of the American Institute of Aeronautics and Astronautics, noted, "The space program has, to a disturbing degree, marked time for the past decade." He sees no change until America is jolted again by another foreign space spectacular, such as when the Russians establish a colony on the Moon.



NASA

Mueller's assessment is for the manned space *program rather* than just for the space astronomy missions. Since 1961 space astronomy has taken a secondary role to the manned program, which was seen as politically more important. Although this secondary role was acceptable when money was plentiful in the 60s, in the 70s the political impetus for space research was gone. NASA's new missions, though designed with care, did not have the appeal as did earlier programs. Also, in order to gain support from Congress, new space missions have, to an increasing degree, had to prove their utility for the Earth's population. Space missions that focus on Earth resources have fared well, but at the expense of missions that look out into space to study the universe.

For a while the coming of the reusable Space Shuttle gave hope to astronomers who wanted to employ sophisticated experiments at lower total costs. They had hoped that the savings from an inexpensive Shuttle launch could be returned in better experimental packages. This hope has been dashed somewhat as technical problems have escalated the costs of the Shuttle dramatically. And even when it flies, experiments that were to be deployed by the Shuttle will have been delayed a few years, creating discontinuities in observational research programs.

All is not gloomy for space astronomy, however. The next decade should see the first space observatories that will serve as long-lived national facilities. Launched into high orbits by the Space Shuttle, these will include general purpose instruments such as the 2.4-meter optical space telescope or the 1.2-meter diameter X-ray telescope. Just as ground-based national observatories operate, the satellite observatories will be used by scientists from numerous institutions. Their long lives will not only permit observing a large number of objects, but also allow astronomers to obtain data, comprehend the significance, and make follow-up observations. The facilities will also provide continuity of observations in a manner that contrasts sharply with the present situtation in which opportunities for observation are often erratic. Because of these features, the national space observatories offer the prospect of making space astronomy an even more integral part of the program for observing celestial phenomena.

I do not predict a future as rosy as the heady years of the 1960s, when money flowed easily into a popular space program. Nor do I see a future as bleak as the 70s, when major programs endorsed by the astronomical community and NASA were axed or severely restricted. I am cautiously optimistic about new facilities that will permit a continuous flow of new space observations.

Of course, much of the future of space astronomy depends on the political and funding support it receives. The space observatories will be the most expensive astronomical facilities ever. But because they will be used by a large number of investigators over a period of many years, they will cost less per researcher than our present orbiting instruments. At the moment, the Space Telescope has received commitments from Congress to be funded into the 1980s, but the X-ray telescope facility and other observatories are not so secure.

In addition to the national space facilities, scientists will also request more money to fly specialized apparatus to complement the general purpose instruments carried in the large observatories. The amount of support these shuttle sortie missions and free flyers will get is, of course, questionable for the long term. For the near term, however, the situation is hopeful as President Carter and Congress continue the policy of the last few years of expanding the space budget. While space astronomers may not receive as much funding as desired, they may not again have to go through the difficult periods of retrenchment that they suffered in the 1970s.

I should finally state that I am not advocating the unquestioned acceleration of funding for space astronomy. In a democracy like ours, in which the federal government sponsors much scientific research, the government must be responsive to its citizens as a whole as well as to the people who directly benefit from its largesse. If congressmen are not convinced that space research will serve a *political* need such as national security or a real and specific benefit such as predicting weather patterns, they are unlikely to authorize funding.

In short, space investigators have become one of many interest groups vying for a slice of the federal budget. In the absence of a jolt such as experienced in 1957 and 1961, space astronomers must engage in the politics of open debate like other interest groups in which they will win some battles and lose others. While the major questions of astronomy may not be resolved as quickly as astronomers would like, at least there will be a modest growth of research opportunities in the 80s for those researchers who are willing to accept the political realities.

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eye
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winter hunting

by
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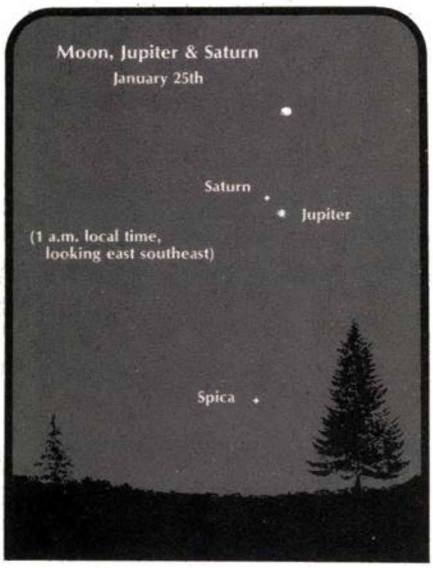
the wanderers

Last year was a great one for conjunctions, and best of all was the series of pairings involving Jupiter and Mars (with the star Regulus nearby). But 1981 begins with a new dance of two planets already in its opening steps: Jupiter overtaking Saturn for the first of three pairings which together form what is called a "Great Conjunction."

These two planets rise side-by-side in the opening minute of the year, but appear much earlier in the evening by the end of January. Yellow-white **Jupiter** beams at about magnitude -1.7, greatly outshining the deeper-hued **Saturn**, whose magnitude is still only about 1.0. On the night of January 13-14, the giant Jupiter edges just 1° 9′ south of Saturn for the official conjunction, but all month the two will be just about as close.

Because these two outer planets are very slow-moving, the speedier one, Jupiter, only catches up with Saturn once every 20 years. But the legendary Great Conjunction to which we will be treated in 1981 is far more rare. If you watch these planets carefully this month, comparing them with background stars (especially the nearby star Gamma Virginis), you will see that at first both are creeping eastward among these stars. Jupiter moves by Saturn just before mid-month but afterwards, both these worlds will appear to halt and start moving back west. This backward or *retrograde* motion is really just an illusion caused by the fact that Earth is then beginning to overtake these planets (the same effect would be seen by a sprinter who raced past two heavy joggers who were in the outer lanes of a racetrack). As you might guess, the retrograde motion brings Jupiter back past Saturn so that a second conjunction occurs next month. The third and final one in the Great Conjunction will take place in July when Jupiter and Saturn are again moving eastward among the stars.

How rare is such a triple or Great Conjunction of Jupiter and Saturn? Well, all of the above can happen only if Jupiter catches up to Saturn just a few months before their oppositions (when both are opposite the Sun as seen from Earth), just before their retrograde motions begin. On the average, that would happen only about once every 125 years, but it actually did occur as "recently" as 1940, when both planets were at opposition on the same day (this, too, will happen in 1981: both reach opposition on March 26). But what about *before* 1940? The next previous Great Conjunction took place in 1683! And even that fact does not tell the full story of how unusual the current planetary positioning is. (More on this next month, when the next Jupiter-Saturn conjunction occurs.)

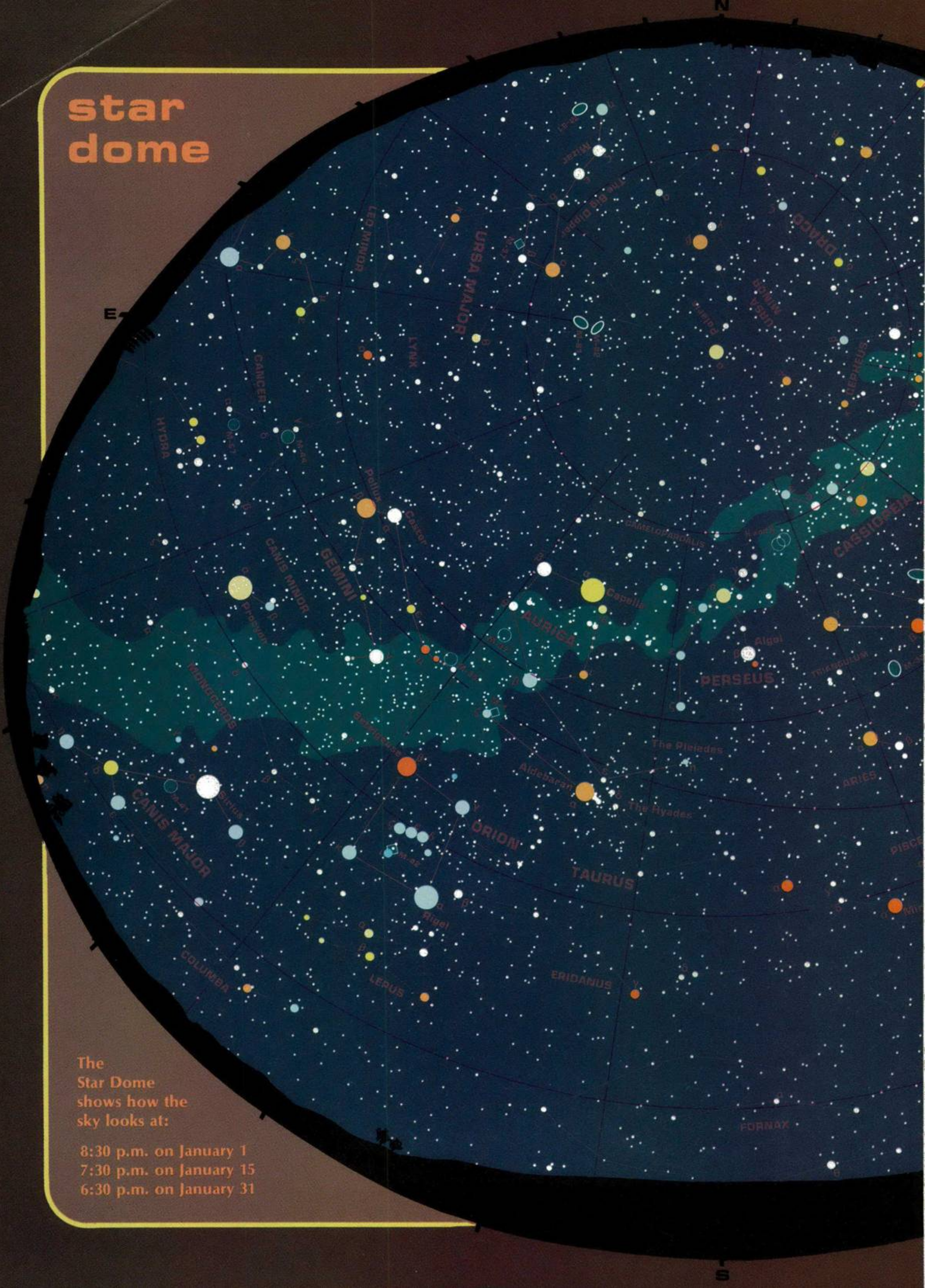


While the two outermost bright planets are forming a rare and beautiful "double star," two other planets are now becoming more difficult to observe. **Mars** is a dim point of light which is on the verge of being lost, low in the evening twilight. On the other side of the Sun, and therefore in the pre-dawn sky, **Venus** is better situated and quite easily seen because of its great brilliance. Venus is near the Moon on the 4th (as Jupiter and Saturn are on the 25th) and takes part in several conjunctions with interesting objects too faint to be seen with the naked eye (see Through the Eyepiece). Venus will be rising as far south as it ever does, more than an hour before sunrise.

Mercury, the last of our five bright planets, is very favorably placed at month's end, and on one night will act as an excellent guide for observers who would like to spot difficult Mars. Mercury seems to zoom up in the after-sunset sky during the course of the month and is near greatest elongation from the Sun as January ends. On the evening of the 23rd, look for Mercury as a brilliant -0.8 magnitude object in the southwest about 30 minutes after sunset. After it has gotten somewhat darker, you may be able to spot the 1.4 magnitude Mars only one-third of a degree south of orange Mercury. This is the closest observable conjunction of the two until 1985, when some observers will see them less than 1′ apart. On the night of January 27-28, Mercury actually passes in front of a 5.2 magnitude star, but this extremely rare event will require optical aid and will

A lovely conjunction of the Moon, Venus, Jupiter, and Saturn greeted early risers who looked east on the morning of November 4, 1980. Saturn and Venus lie along the TV antenna with Jupiter at upper right; below the Moon and a little to the left is the star Gamma Virginis. Photo taken from Milwaukee by Robert Burnham.

star dome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ARIES
CANIS MAJOR
M-41
Sirius
ORION
M-42
TAURUS
PISCE
Rigel
COLUMBA
LEPUS
ERIDANUS
FORNAX

The Star Dome shows how the sky looks at:

8:30 p.m. on January 1
7:30 p.m. on January 15
6:30 p.m. on January 31

january sky almanac

1st The Earth is closest to the Sun tonight at 9 p.m. EST: 91.0 million miles.

2nd Late tonight and early tomorrow morning, look near the border of Hercules and Bootes for many fast, but faint, meteors from the Quadrantid shower.

4th Moon lies to upper left of Venus in the east shortly before sunrise.

5th Venus lies below Neptune in predawn eastern sky.

6th Moon is New at 2:24 a.m. EST.

7th Look for Mars below a very thin Moon tonight in the western sky after sunset.

13th First Quarter Moon: 5:10 a.m. EST.

14th Jupiter passes south of Saturn tonight. Also, Moon closest to Earth (perigee) at 11 p.m. tonight: 229,710 miles.

16th When the sky gets dark tonight, look for Aldebaran just to the west of the Moon.

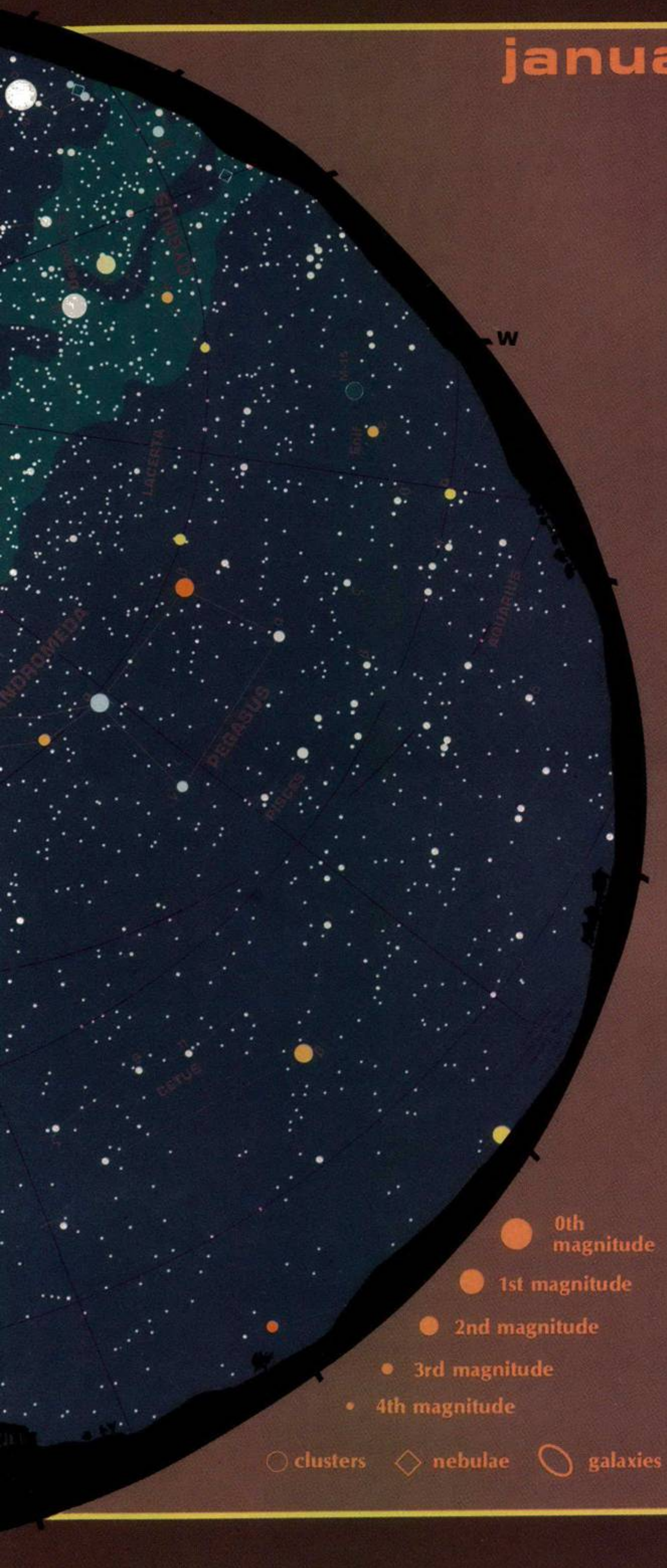
17th Beginning now and for the next 3 to 4 weeks, Mercury will be low in the west-southwest after sunset.

20th Full Moon comes at 2:39 a.m. EST.

23rd After sunset this evening, look low in the southwest to see Mercury near Mars.

25th The gibbous Moon will pass Saturn and Jupiter tonight.

27th The Moon is at apogee (farthest from Earth) this afternoon at 3 p.m. EST: 251,227 miles. Also at Last Quarter tonight: 11:19 p.m. EST.


CYGNUS
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CETUS
M-15
W
0th magnitude
1st magnitude
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

The pinky-yellow glow of distant aurorae throws low-lying drifts of cloud into silhouette, while above swings the Big Dipper. Richard Berry placed his camera (with a 50 mm, f/1.4 lens) on a tripod and exposed 400 ASA slide film 20 to 25 minutes to record this photo at Ross Lake in the Upper Peninsula of Michigan.

probably be visible only in Hawaii and the Pacific. During the last week of the month, Mercury gets a little fainter, but it's higher and easier to see.

There is an assortment of other interesting events involving solar system bodies this month. See Through the Eyepiece this month for information on a penumbral eclipse of the Moon and a potentially good showing of the Quadrantid meteors. If you have very dark skies and want a real challenge, look for 6.5 magnitude asteroid **Ceres** as it passes 1-1/3° south of Pollux on New Year's Eve. (If you miss Ceres, Vesta will be less difficult next month.) And on that same evening, consider the fact that **Earth** is at perihelion (only 98.3% of its average distance from the Sun) — but it's still quite cold in the northern hemisphere because we are tilted away from the Sun at this time of year.

the starry sky

Some observers believe that winter nights are the most crystal clear of them all. Is this really true? The answer depends on where you live. Nowhere in the continental U.S. are the winter months the least cloudy in terms of the actual percentage of sky covered with cloud. But that does not answer the question of when you may expect the very clearest nights — those occasions when the brighter stars stand out with wondrous prominence and crowds of additional stars can be seen.

There is a reason why winter evenings may *seem* most transparent: no season has so many bright stars as winter. Even the summer constellations cannot compare with the brilliant diamonds scattered over the evening sky in January. This month's starshine really is worth braving the cold for a while!

You can see for yourself on the next clear night. The best place to start is with the centerpiece of the winter array, the brightest constellation in the heavens: **Orion** the hunter. Mighty Orion, his unforgettable three-star **belt** aglitter, is at his hightest around 9 p.m. in the latter part of January. The line which runs from due north through the zenith to the southern horizon is called the *meridian*, and when Orion is on that line — *culminating* is the technical term — the human-like figure of the Hunter has, coincidentally, become perfectly upright.

Most of Orion's stars are blue, because they are hot, young stars. The brightest of these "blue giants" is **Rigel**, located in the western knee. But diagonally across from Rigel (above the belt) is a beautiful exception, the brightest red star in the sky, **Betelgeuse**. This star with a peculiar name (meaning "armpit of the giant") is somewhat dimmer than Rigel, but it may be the largest Sun which we can observe with the naked eye. If Betelgeuse were in our own Sun's place, it would fill the solar system out to the orbit of Jupiter.

Orion also has his **sword** (the line of moderately bright stars running down from the belt) and is pictured wielding a club and lionskin shield. This battle-gear helps ward off the attack of **Taurus** the bull, facing Orion from the west. The star representing the bull's eye, usually a little fainter than Betelgeuse, is **Aldebaran**, which only seems to be a part of the V-shaped **Hyades** cluster (the cluster is actually much more distant). West of the Hyades and Aldebaran, whose name means "the follower," is the object which both Aldebaran and Orion follow: the lovely star cluster of the **Pleiades** or the seven sisters. Up above the Hyades are the two stars on the bull's horns. The fainter of these lies near a famous telescopic object, the fascinating Crab Nebula — the remains of the supernova which in July 1054 A.D. was brighter than Venus.

For observers in the U.S., the zenith at mid-evening in January is held by **Auriga** the charioteer. This pentagon of bright stars is connected to Taurus and features brilliant yellow **Capella**, slightly brighter than Rigel. Capella means "she-goat" in Latin and the little triangle of stars near it are **the kids** — these animals are being carried by the charioteer. Auriga contains several star clusters visible in binoculars and you might even glimpse the best of them, **M-37**, with the naked eye if your skies are very dark (it is identified on the Star Dome map).

Sloping west from Auriga are several fine constellations which we have looked at in the past few months and which still deserve attention: **Andromeda** with its famed galaxy, **Cassiopeia** still high in the northeast, and **Perseus** just next door to Auriga and the Pleiades. But east of Auriga, to the upper left of Orion, is a prominent star pattern which is still climbing. It is **Gemini**, the twins, named for the famous brothers of Greek mythology, whose Roman names are applied to this constellation's two brightest stars, **Pollux** and **Castor**. Pollux is slightly orange and slightly brighter than Castor, which just misses being considered a first magnitude star according to the old traditional listing.

Also still ascending this month are Orion's dogs, who follow him across the sky, possibly also chasing little **Lepus** the hare who is found scurrying away from beneath Orion's feet. (Even farther below, under Lepus, you may just glimpse very southerly **Columba** the dove.) **Canis Major**, the big dog, contains the heavens' brightest star, **Sirius**. If you are not yet familiar with the famous dog star, now is a good time to make its acquaintance — but do not overlook the bright star in **Canis Minor**, the little dog. This star, **Procyon**, is often said to be slightly yellow — see what you think. While admiring the two dogs, notice that the space between them is quite devoid of bright stars. This is the region of dim **Monoceros** the unicorn, but through it runs a rather bright section of the winter Milky Way.

Cancer the crab and the head of **Hydra** the sea-serpent are lower in the east and the mighty form of **Leo** is now crouching just over the eastern horizon. But these are the vanguard of spring, and spring is far away these chilly nights. Yet Leo may bring you some comfort in another way: he is the forerunner of the spectacular Jupiter-Saturn pair which rises not long after him.

skylore

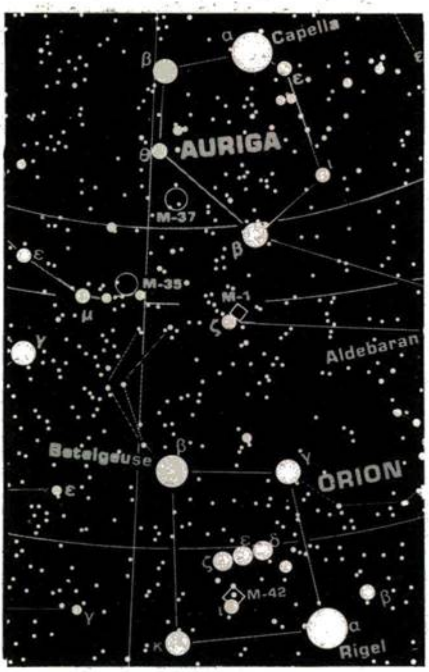
In many cultures, the constellation we call Orion has represented one of the chief deities. That is not surprising, considering the constellation's brightness and the fact that its rather symmetrical pattern does suggest the form of a person. But in the largest Western mythologies, the Greek and the Norse, the figure connected with this star pattern is neither a god nor at all a central character in the mythos. In both cases, however, the tales attached to this giant hunter-traveler are rich and imaginative.

Orion of the ancient Greeks was usually called a son of Poseidon, the great sea-god, but his mother was variously considered Earth herself or Euryale — one of the three Gorgons, those women who had been made petrifyingly repulsive as a punishment for their vanity. The most famous of the Gorgons was snake-haired Medusa whom Perseus beheaded, but her sisters were immortal. It may seem strange that Orion, who was described as being the handsomest of all men, would be a child of Euryale, but remember that she was beautiful before being punished. If Medusa conceived fair Pegasus before she was made hideous, then perhaps Euryale could indeed produce the beautiful Orion. One question remains unanswered (as far as I know): how could immortal parents (Poseidon and either Earth or Euryale) produce a son who was mortal? For mortal Orion certainly was, as we shall see.

Besides being the handsomest of men, Orion was also the tallest. So tall was the Hunter that he had no need for boats: when his feet were on the sea floor, his head was still above the waves. (According to another version, Orion could actually walk on the surface of the water, because he was a son of Poseidon.)

Despite (or perhaps because of?) his physical gifts and talents, Orion seems to have been more than a little rash and unwise. He performed the mighty task of hunting down all the beasts in the kingdom of Chios so that he could win the maiden Merope (no relation to the Pleiad sister of that name). But when her father, the king Oenopion, reneged on the deal, Orion got angry and either threatened the unscrupulous man or overwhelmed and violated Merope. But Oenopion (with the help of the god Dionysus) was able to get the giant into a drunken stupor and then blind him.

The hunter was definitely in a plight, but he was told by an oracle that he could regain his vision by going to the easternmost lands and letting the rising Sun there bathe his eyes. But he needed a guide. So Orion followed the sound of ringing hammers to the forges of the blacksmith god Hephaistos. The god could only spare one of his assistants, the Cyclops Cedalion, who was lame. This was no problem for Orion, however, for he was so strong that he was able to carry the huge Cyclops on his shoulders like a child. Cedalion's one eye served them well and they arrived at the east of east where the sunrise healed Orion's eyes — but not before Eos, the Dawn, was smitten with him and invited him to her bed.



After his healing and scandalous affair with Dawn, Orion returned to mortal lands, chased the Pleiades sisters (whom Zeus saved by turning them into doves that flew to heaven), and eventually took up with Artemis, virgin goddess of the hunt. Artemis, who had always been cold to men, soon fell passionately in love with Orion and would have had him for husband if his death had not intervened. Some say that Hera got angry at Orion's boast that he could kill any animal and she sent a giant scorpion to slay him. According to this account, the gods were merciful and placed Scorpius as far away from Orion as possible when both were transported to the heavens. A more popular version, however, claims that Apollo, the beautiful brother of Artemis, was jealous of Orion and tricked his sister into shooting a distant target far out to sea, which turned out to be Orion on one of his aqueous ramblings. The arrow killed Orion, but Artemis was so grieved that Zeus agreed to place him among the stars as the heavens' most glorious constellation.

ASTRONOMY
REVIEWS

The Right Stuff
Tom Wolfe
437 pages, hardcover, $12.95
Farrar, Straus, and Giroux (1979)
and
Of a Fire on the Moon
Norman Mailer
472 pages, hardcover, out of print
Little, Brown and Company (1970)
and
Post Orbital Remorse, selected
articles from *Rolling Stone*
Tom Wolfe

What a glorious moment it was when mankind first tentatively stepped out into the soft darkness of space. The date was April 12, 1961; our representative, Yuri Gagarin. Here was an infinitely expanding frontier indeed — what magnificent vistas were to be ours. We could explore unimagined sights. We could share in the wonders of "being here, in this marvelous world, in this marvelous desert, in this marvelous time," as Carlos Castaneda had Don Juan Matus say. "For me," he said, "the world is weird because it is stupendous, awesome, mysterious, unfathomable," and out there in space was an unparalleled opportunity for us to relish this mystery. Our journey into the heavens was to be done with care, with respect for what is out there, and with love and thoughtfulness for this bounteous and beautiful planet which has given us life and the opportunity for witnessing the marvels of the cosmos.

But of course, mankind being what we are, we immediately half-botched the job of space exploration and made it into a sodden political football. Cold war, not peace. Competition, not cooperation. Not enough that we kill so many of our fellow beings on this planet. Not enough that we exploit and "develop" here. No — immediately the greed and the hunger for power, the thought-lessness and care-lessness of us humans began infesting the space program. We were going to "colonize" space, as though the universe didn't already have more humans than it needed as a consequence of our insane urge to reproduce ourselves to the saturation point. Such deep ambivalence has dogged our efforts to explore and enjoy space throughout the brief history of that adventure.

Still, for many of us, nothing could damp our enthusiasm for space, and the first full flush of excitement lasted for more than a decade, peaking perhaps on July 20, 1969, when another of our representatives, Neil Armstrong, became the first person to touch another celestial body. We had begun to explore the stars which gave us birth. In the summer of 1975, with the Apollo-Soyuz, American-manned space missions ended.

Since then, we space fans in the U.S. have fed on slim pickin's, what with the best part of a decade-long hiatus in American-manned space programs, the paucity of information from Russia, and the timidity of the American press in publicizing what information is available. Few American space buffs even realize that Russia has had what is in effect a permanent space station in orbit around the Earth for almost three years now, with visiting scientists going up for experiments, mail delivery, and companionship with the permanent staff and then returning to Earth with data and cargo needing repairs to be sent back up later.

What's a poor American space freak to do? Fortunately, we humans have a conscious memory and thus a history, so we can relive the entire hypnotic story. I do so often, using three dense, complex but exciting books which together portray the full range of both the woe and the wonder of America's share in this drama. The first act is presented in the most recently published of the three — *The Right Stuff* by Tom Wolfe — which recounts the background of the space program in the U.S. and the selection, training, and achievements of the Mercury astronauts.

Such a dry statement hardly conveys the raw excitement of Wolfe's prose, the most captivating of any American writer today. With the first sentence one is embarked on a spellbinding journey as fast-moving as the "booming and zooming" of the experimental rockets that were to transport us into space and as irresistible as the "enormous egos" that rode them. For that's what Tom Wolfe is interested in enabling us to experience — the real ambitious-petty-glorious-individual human story and the real sordid-hilarious-uncensored - political / institutional story of the Mercury space flight program.

We relive the early hysterical days in America after Sputnik (October 4, 1957) when there "was an emergency meeting (*What* emergency?) of government, military, and aircraft industry leaders" to plan the "Man-In-Space-Soonest" project (MISS!), which meant using the "quick and dirty approach," more colorfully called the "cowboy operation," where you don't have time for scouting reports on possible hostile Indians, you just ride at full gallop over the next hill into whatever ambushes might lurk on the other side. You may remember how a U.S. rocket launch would be announced with much fanfare for national live television with breathtaking countdown followed by "a mighty surge of noise and flames, and the rocket lifts — some six inches, the first stage, bloated with fuel, explodes, and the rest of the rocket sinks into the sand" of the Florida coastline, or worse than that, the rocket lifts and "heads off on some crazy trajectory, toward downtown

Orlando instead of outer space, in which case it had to be blown up by remote control."

"Our rockets always blow up," became an unspoken fear.

It was truly funny, especially to that rare breed of crazies, the "fighter jocks," the ones with the "Right Stuff," the test pilots of the X-1 or the X-15 or the "F-102," or any of the military's other marvelous bricks with fins on them." These were highly skilled pilots, with lightning reflexes honed to a fine point, testing with their very lives any half-baked machine someone could dream up on the drawing board.

But now they were being asked to go up in capsules, little cramped pods you couldn't even see out of, to sit passively in containers, not ships, requiring no more flying skill than...why, than a monkey has. It turns out that "a monkey's gonna make the first flight" — and a wired-up neurotic speed freak of a monkey at that. The test pilots roared at the idea. "Spam in a can" is what the hot jocks at Edwards AFB like Yeager or Armstrong or Pete Conrad or Wally Schirra or Shaky Lovell called Project Mercury. It was "the human cannonball approach, a Larry Lightbulb scheme, and it gave off the funk of panic." They preferred the X-15 rocket ship, which one *flew*, which one would "land with dignity" rather than be fished — at best! — ignominiously out of the water like a worm in a rusty tin can.

Do you begin to detect an irony in the very title of the book? — "the right stuff" indeed! The whole story is replete with such ironies.

A beautiful case in point is the second manned suborbital flight in the Mercury capsule by Gus Grissom. No greater sin hath a test pilot than to lose the test vehicle and that's just what gloomy-Gus did. The capsule sank in three miles of deep sea water — and still he was counted a hero!

Or the press conference when the seven Mercury astronauts were first introduced to the nation. Talk about ironies: these seven hell-for-leather, foul-mouthed, wenching hotrodders well-known to the local citizenry for drunkenly terrorizing the highways at night in their flashy cars — "Flying & Drinking and Drinking & Driving and Driving & the rest" — were, through the bland-faced charm of one man, Marine Lt. Col. John Glenn (with some help from press and politicos), transformed into "the Holy Seven," each an "amazing picture of the Perfect Pilot wrapped up in a cocoon of Home & Hearth and God & Flag!"

Tom Wolfe presents the entire unlaundered demythologized story in magnificent prose that pulls not a single punch. For, make no mistake, he writes for contemporary adults, not for Victorian gentlechildren who watch TV or read the *New York Times*. In his hands, Act One of our space drama is high comedy (and some not so high) as the narrative breaks off in 1963 after the last Mercury flight (Gordon Cooper) and the last attempt to break the world's altitude record by a ship taking off under its own power (Yeager). But along the way we've been shown not only the tragicomedy of hysterical space-age dueling, but we've also been treated to those rare moments of unalloyed beauty as man hovers on the brink of outer space.

* * * * *

Act Two is more well-known and therefore appropriately more somber in the telling — and happily for us space junkies, also more technologically detailed. It is Norman Mailer's *Of a Fire on the Moon*, another book for mature readers only (of whatever age). America has no better writer than Norman Mailer for portraying who we are by examining our insides, our unconscious, our depths. He is at his provocative best in this book, which focuses directly on the historic nine-day flight in July 1969 of Apollo 11, with

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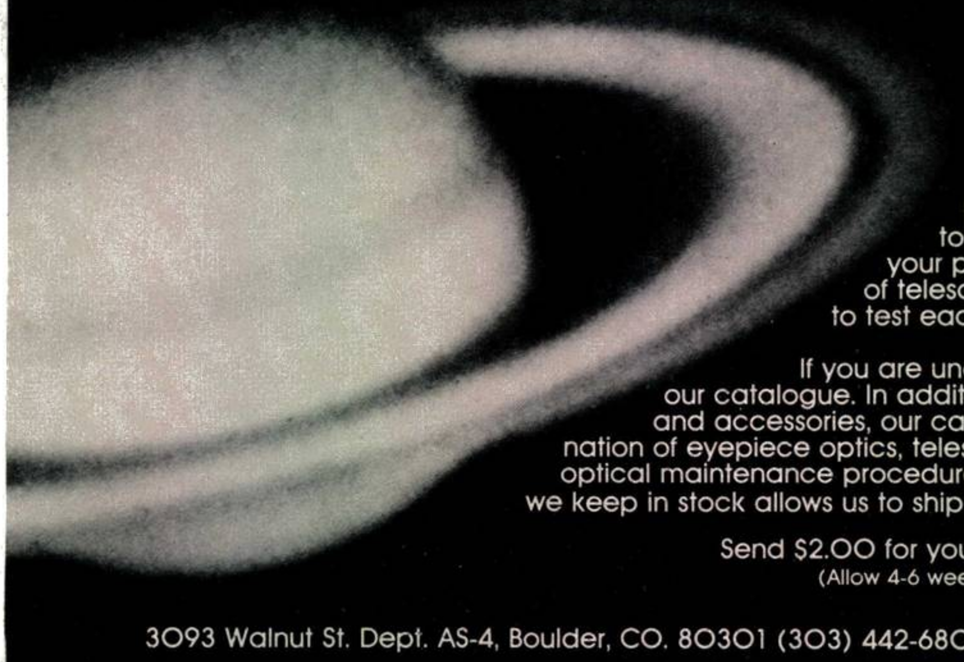

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Columbia and Eagle, with Armstrong, Aldrin and Collins, to the Moon, on it (incredibly walking on the moon!), and then back.

In point of fact, Mailer tells the complete story twice, once with narrative suspense driving languid considerations of what it all means, then once again with nearly three hundred pages detailing every conceivable technological aspect of the flight. No mechanical or electrical dimension of the launch and mission is left unmentioned. All the things one wondered about are presented in exhaustive descriptions: the fifteen miles of wiring, the two million functioning parts, and the eighty-seven different motors of the Command Module alone. One gorgeous long two-page sentence describes practically all the six hundred and fifty switches, dials, meters and diplays on the bank of instruments facing the astronauts. Other sentences portray the complex means of storing and injecting the fuel, the intricate, almost sexual way the Command and Service Modules fit together and separate, the ubiquity of digital computers, the various officials in the Missions Operations Control Room (MOCR) in Houston, the intricate multi-layered moon-walk space suits, the food and toilet arrangements, the awesome Vehicular Assembly Building (VAB) whose size in cubic feet surpasses the Merchandise Mart in Chicago and the entire Pentagon combined, the mechanical devices controlling the first six inches of flight after lift-off, the drudgery of minute tasks to be performed by the astronauts complete with pages-long transcripts of flight transmissions during and about those chores...the list never stops.

The glory is not all technological, however. Mailer's portrayal of the Moon, for example, plain and beautiful, mundane and mysterious, will send even the most jaded astronomer back to his telescope. Listen to this description of Aristarchus: "...the most mysterious of the observed craters. Its reflected light seemed brighter than any other crater, and it had given evidence over the years of possessing some kind of local atmosphere, some hint of clouds or emissions of gases. Areas of the crater would glow bright or grow dim in unaccountable fashion, as studied through the telescope, and its most luminous period would tend to come at the beginning of the lunar day when the change from cold to heat was greatest, rather than at the midday when the Sun was overhead." In fact, Neil Armstrong's account of Aristarchus as viewed while orbiting the Moon hints at just this mystery: "There's an area that is considerably more illuminated than the surrounding area. It seems to have a slight amount of fluorescence to it...one wall of the crater seems to be more illuminated than the others." This is just one of scores of such moments, scintillating in their beauty and excitement, linking high technology and natural wonder.

But underneath all, for Mailer, is the question of meaning. As sharply as Wolfe, and much more flamboyantly, Mailer points up the vast contradictions involved in the effort to put an American on the Moon in the 60s. To his credit, Mailer does not tilt the scales either way. In fact, he admits "that he hardly knew whether the Space Program was the noblest expression of the Twentieth Century or the quintessential statement of our fundamental insanity." He explores fully the daily and minute manifestations in the American manned space program, our collective "national itch to dominate the world, the contrasts and harsh comedies of race and war and pollution," demonstrating again and again how the manner of the entire endeavor was "a sublimation of aggressive and intolerably human desires, as if like a beast enraged with the passion of gorging nature, we looked now to make incisions into the platinum satellite of our lunacy, our love, and our dreams."

Such language is purple only if one forgets the realities it describes, for America's schizophrenia was fully operative in Apollo 11, a flight whose thrill and terror were both an obvious end-product of the "wild nihilism of the Wasp, that laser of concentration and lack of focus on consequence" which is so characteristic of us.

If Mailer can speak of Americans as "the most Faustian, barbaric, draconian, progress-oriented and root-destroying people on Earth," he also enables us to relive the novel experience of "our first step back to the stars, first step back to joining that mysterious interior material of the stars, that iron of communion in the cosmic origins." Who can forget Armstrong's words: "Houston, Tranquillity Base here. The Eagle has landed." Mailer recalls his reaction: "Aquarius discovered he was happy. There was a man on the Moon. There were two men on the Moon. It was a new feeling, absolutely without focus for him. Well, think of that, he had said." And Mailer has done just that for us — think of it. And he makes us do the same.

* * * * *

The final act of our drama returns to the comic vision. Just as well — how better to deal with the pain of loss and frustration at the unnecessary ending of something hardly just begun. The author is again Tom Wolfe and the book, *Post-Orbital Remorse*, is unfortunately not available except in its original appearance in four long parts in *Rolling Stone* early in 1973. There is only a little overlap with *The Right Stuff.* (Specific information on this series of articles is given at the end of this essay.)

The title is well-chosen, for this book portrays the inevitable let-down as the American manned space program concludes. Specifically, it traces the individual ways particular astronauts dealt with the problem of having achieved their highest goal, being acclaimed worldwide for it, and then being ignored and eventually forgotten. Post-orbital remorse, indeed!

Wolfe, like Mailer, has felt the need to tell the story twice. The book traces the narrative from the beginning, and the humor is still there — but if possible it's both blunter and sharper. The narrative drive is breathless as well as hysterically funny, and so we are quickly brought into the 70s, after the first Moon landing.

Plots broken off in *The Right Stuff* are resumed as we learn what happened to the Mercury astronauts and meet the Apollo crews. The point of view is peculiar — an entire book written as though the Collective Unconscious of all the astronauts were talking to Tom Wolfe, trying to get him to understand and experience their reality. He succeeds magnificently.

We live the suspense of various flights, the snufflings of the press, the adulation which follows success. But then the implacable end overtakes each astronaut — you're not going back up, there'll be no more cheers, you've made your last space flight. Sometimes it happens quickly and all too soon, as with Scott Carpenter and John Glenn. Sometimes it's drawn out in an agonizing manner, as with Gordon Cooper who got up twice, in '63 and '65, but never again, bumped and bumped from flight to flight, but never in space again. Sometimes it seemed long since all over, as with Al Shepard, first American in space, who developed an ear difficulty and washed out of the program early, only to reappear once more, out of nowhere, a decade later in Apollo 14.

Or the dramatic soap opera story of Deke Slayton, premier hot jock who developed what looked like a bad heart and never made it up, flight after flight, Mercury program ended, ten Gemini flights, nothing, Apollo Moon program over, then had a dangerous exploratory heart operation and miraculously, at the age of 52, hitched a ride on the very last manned space ship the U.S. sent up, Apollo-Soyuz, in 1975. But then even he, along with all the others, knew it was his last time up.

Some turned to politics to get the adulation their egos needed. Some went mystical and psychic. Some went bananas, completely around the bend for a while. Some tried to cash in on it all. Some got religion. But it was over, over for them all. And over for us.

For many Americans, space dribbled away in boring bits and pieces. The television ratings dropped, the reason being, as Wolfe caustically notes, that NASA was too successful and consequently had this "big PR trouble: nobody was getting killed!" If one knows America, one shudders at the accuracy of that judgment.

The ratings dropped, nobody was interested, the space race was over, no more rockets blowing up or death-defying feats, we'd beat them Rooskies, so forget all that and find a new thrill. The astronauts might have post-orbital remorse. America was too blind, unconscious to see that anything *was* over, that there was anything to be remorseful about.

So it is to this very day. As our space budget threatens to sink like Grissom's Mercury capsule, the only thing keeping it afloat is the DOD. I find many, many Americans still excited by the possibility of space flight, any kind of exploration, manned, unmanned, "our" space flight, "their" space flight, — any kind at all.

And on those cloudy nights when Earth's delightful atmosphere closes in on us, we turn to those creative writers, geniuses of imagination, who enable us to relive experiences we never even had. Let Tom Wolfe take us back to the Moon, to "the sensation of the Moon's horizon. Sensation, because it isn't merely a piece of visual data. It is something that your body somehow feels. Try to imagine you're on a beach one day and you look out across the water and suddenly that immutable distance to the horizon has been reduced by three-fourths — and the horizon seems to be closing in on you. It has closed in to within 6500 feet, it's right. . .here. . .in front of you, and not only that, it bends down to the left and the right, falls off in curves. Well, that's the lunar horizon. For the first time in your life you actually experience the sensation of standing — living! — on top of a huge ball, and out beyond you is the Earth, glowing, blue and green, and now unmistakably a ball, sailing in a black infinity full of glowing balls, not the nice homey fuzzy twinkly stars you see on Earth but golden bowling balls humming around in the cosmic gyro — the galactic flash — well, this is a sensation that flashes through every electrical conduit in your body, through every dendrite, every synapse, and it does something to you."

So can we all continue to thrill to the strangeness and charm of all those incredibly different worlds out there. Let us return again tonight, through telescope or through Wolfe and Mailer, to the stars from whence we literally originally came.

John Mood
San Diego, CA

Note: Tom Wolfe's *Post-Orbital Remorse* may be found in the following issues of *Rolling Stone*:

"Part One: The Brotherhood of the Right Stuff"; #125 (January 4, 1973); less than a fifth included in *The Right Stuff.*

"Part Two: How the Astronauts Fell from Cowboy Heaven"; #126 (January 18, 1973); slightly less than half included in *The Right Stuff.*

"Part Three: The Dark Night of the Ego"; #128 (February 15, 1973); none included in *The Right Stuff.*

"Part Four: The Last Great Galactic Flash"; #129 (March 1, 1973); none included in *The Right Stuff.*

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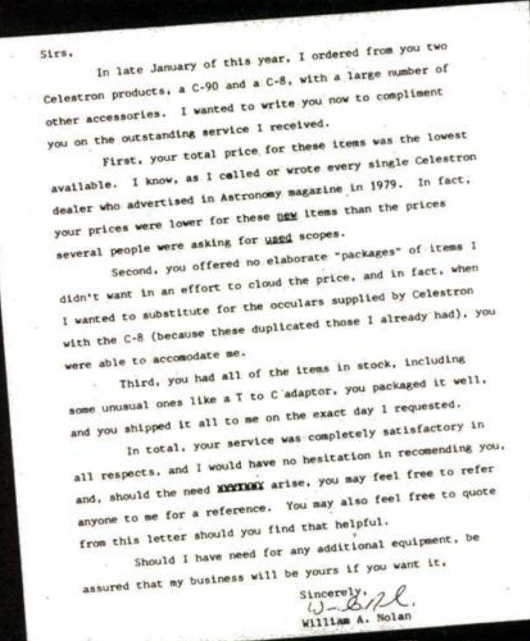

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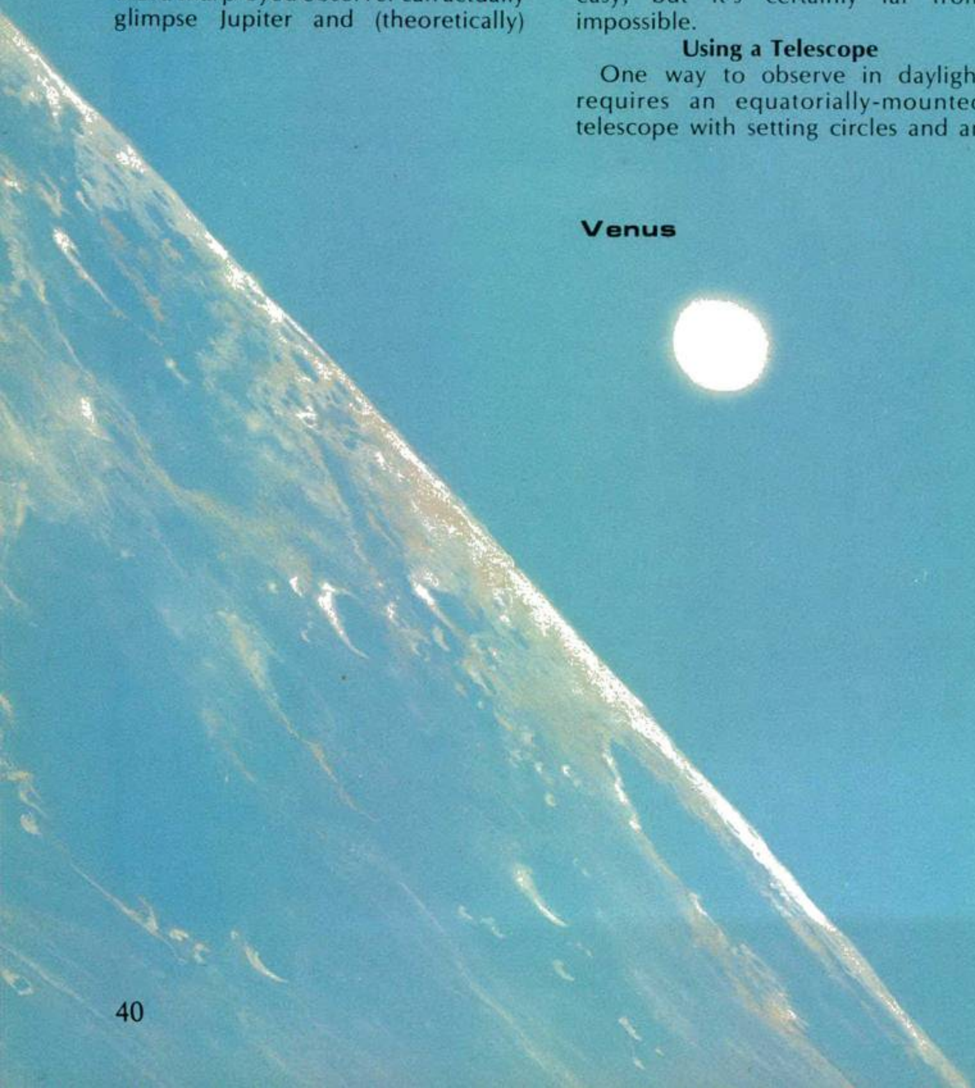
gazer's gazette

observing planets in the daytime

by Larry C. Sessions



Venus

People who spend most of their time indoors are often puzzled when they spot the Moon in daylight. It looks big and bright and close as its visage penetrates the blue veil of the daytime sky, but to many it is "only supposed to be out at night!" The fact that you can often see Venus on a sunny day — provided you have good eyesight and know exactly where to look — also surprises many beginning skywatchers. But even some long-time astronomy enthusiasts don't realize that a sharp-eyed observer can actually glimpse Jupiter and (theoretically) Mars during the day — at least under certain circumstances.

What's more, with a telescope, many bright stars are visible and have been used by surveyors and explorers to determine their geographic position. There's little practical reason for you to observe stars during the day, but observing a planet in daylight offers decreased background contrast, and occasionally a calmer atmosphere that may actually enhance observations. Seeing planets during the day isn't easy, but it's certainly far from impossible.

Using a Telescope

One way to observe in daylight requires an equatorially-mounted telescope with setting circles and an accurate clock drive. First, locate the planet in the dark, predawn skies (this is possible, of course, only for certain times and positions of the planet). Having found the planet (or bright star), center it in a low-power/wide-field eyepiece and turn on the right ascension drive. Assuming your instrument is well-aligned on the celestial pole, that it tracks well in R.A., and that there are no trees, buildings, or whatever to obscure the view, the planet should be visible in the eyepiece even after sunrise. It may be difficult to see against such a bright background, though, so prefocusing the telescope before daylight is a must.

A popular alternate procedure can be used entirely in daylight. Using the *Astronomical Almanac*, look up the declination and right ascension of both the Sun and the planet for the date and time of observation. Aim the telescope at the Sun (being very careful!), and by eyepiece projection, center it in the field of view of a wide-field eyepiece. Next, shift the telescope in declination by an amount equal to the difference between the declinations of the planet and the Sun. (Be sure you know whether the difference is north or south!) Then, using the right ascension circle, move the telescope in right ascension the proper distance. The planet will now be in the field of view, or a little sweeping of the area should uncover it. This method works especially well with the inner planets Venus and Mercury, which are always near the Sun.

Of course, you can always find the planet or star by setting circles alone, but this requires a sidereal clock as well as an exceptionally well-aligned mounting and very accurate circles.

The Unaided Eye

Under excellent conditions, a keen-eyed observer may be able to see Venus, Jupiter, or even Mars without any optical aid, by using the telescope as a pointer. But it is unlikely — and perhaps impossible — for the unaided human eye to observe Jupiter or Mars when the Sun is more than a few degrees above the horizon. Daytime observations of these planets with the unaided eye are effectively restricted to just after sunrise and just before sunset.

A useful way to observe a planet in daylight without equipment requires excellent eyesight and a particular set of circumstances. The procedure is simple. Using Through the Eyepiece, an ephemeris, or the almanac, find the time when the Moon and the planet are in close conjunction and above the horizon during the day.

Mercury

Then, at the time of the conjunction, locate the Moon (this will usually be easy except when the Moon is a thin crescent — a very bad time to look anyway). Knowing the location and distance of the planet from the Moon, search the appropriate area. If you can't see anything by eye, try binoculars. It may be a long and fruitless search, or the planet may suddenly appear as a tiny white dot in a sea of blue. If you see it in binoculars, try again without them.

One great difficulty you'll often experience is that as your eyes scan the featureless sky, they don't keep their focus on "infinity." This sometimes makes finding that tiny point of light very hard! Give your eyes a rest from time to time or you'll soon have them both watery and bleary.

The easiest opportunities for spotting a planet arise when the planet and a first or third quarter Moon are in conjunction around sunset or sunrise. For Jupiter, Saturn, and Mars, especially, these circumstances help considerably since they insure that the Sun is low and the planet high in the sky. And, as we've seen, locating the planet is made easier by its nearness to the Moon. Remember too that Mars varies considerably in brightness and is unlikely to be seen except near its brightest.

Mars

Pushing to the Limit

Although theoretical and empirical studies published in the 1940s and 1950s suggest that the unaided eye can actually see Mars and Jupiter even when the Sun is as high as 15° above the horizon, such sightings are extremely difficult.

Specifically, a celestial object should be at least as bright as magnitude -2.1 in order to be seen when the Sun is 15° in altitude. Therefore, Sirius, the brightest star (magnitude -1.6), would never be visible without optical aid whenever the Sun is 15° or more above the horizon. How long after sunrise can *you* find it?

Daylight observation of planets and stars is a difficult and challenging pursuit, comparable to looking for the very young or very old phases of the Moon. A large number of variables can affect your results: cloud cover, altitudes of Sun and planet in the sky as well as that of the observer on Earth, magnitudes, optical equipment used (if any), and visual acuity of the observer. But however difficult it may be, there are a few ways to make it easier.

Saturn

To minimize the amount of obscuring air through which the light must pass — and to reduce sky brightness — try to observe the object when it is high in the sky and the Sun is low. Observe from as high an altitude as possible. An observer in Denver or Salt Lake City will find it easier (all else being equal) than the observer at sea level, but persistence and a well-planned observing program will insure success for observers with good eyesight, regardless of location.

As with all daytime observing, though, be very careful not to look at the Sun directly. Every year the number of otherwise intelligent people who do such a foolish thing is amazing!

If a good, equatorially mounted telescope isn't available, locate the object first in binoculars, making sure that they're prefocused at infinity. Experiment with polarizing filters to see if they darken the area of sky being searched. Remember that the sky is most polarized 90° from the Sun — about halfway across the sky. Other filters, especially orange or orange-red, can be very effective in reducing background light and increasing contrast. (If you have a telescope, try using these same filters.)

Sirius

Daytime observing can become a collecting hobby: you can "collect" observations of the planets and stars during the day. Or you can compete with other observers, striving to be the first to see certain daytime objects or looking for them at a particular time of day or with specific equipment.

Sometimes the planet or star seems to stand out brightly and you wonder how you could have missed it before. The next minute you've lost it again. Once you've seen your first daytime object, however, the excitement is infectious and can open up a whole new world of astronomical observations for you.

Don't be discouraged if you don't succeed at first. This requires good eyesight and boundless persistence — it's hard to pick out that tiny dot of light against a bright background. You'll be amazed at the way practice improves your ability in daylight as well as in nighttime observing.

Jupiter

But don't give up night observing. To paraphrase an old proverb: "There's a time for every observation under heaven."

Larry Sessions has spent eight years as a planetarium educator, and is currently in charge of public relations for the Gates Planetarium in Denver, Colorado.

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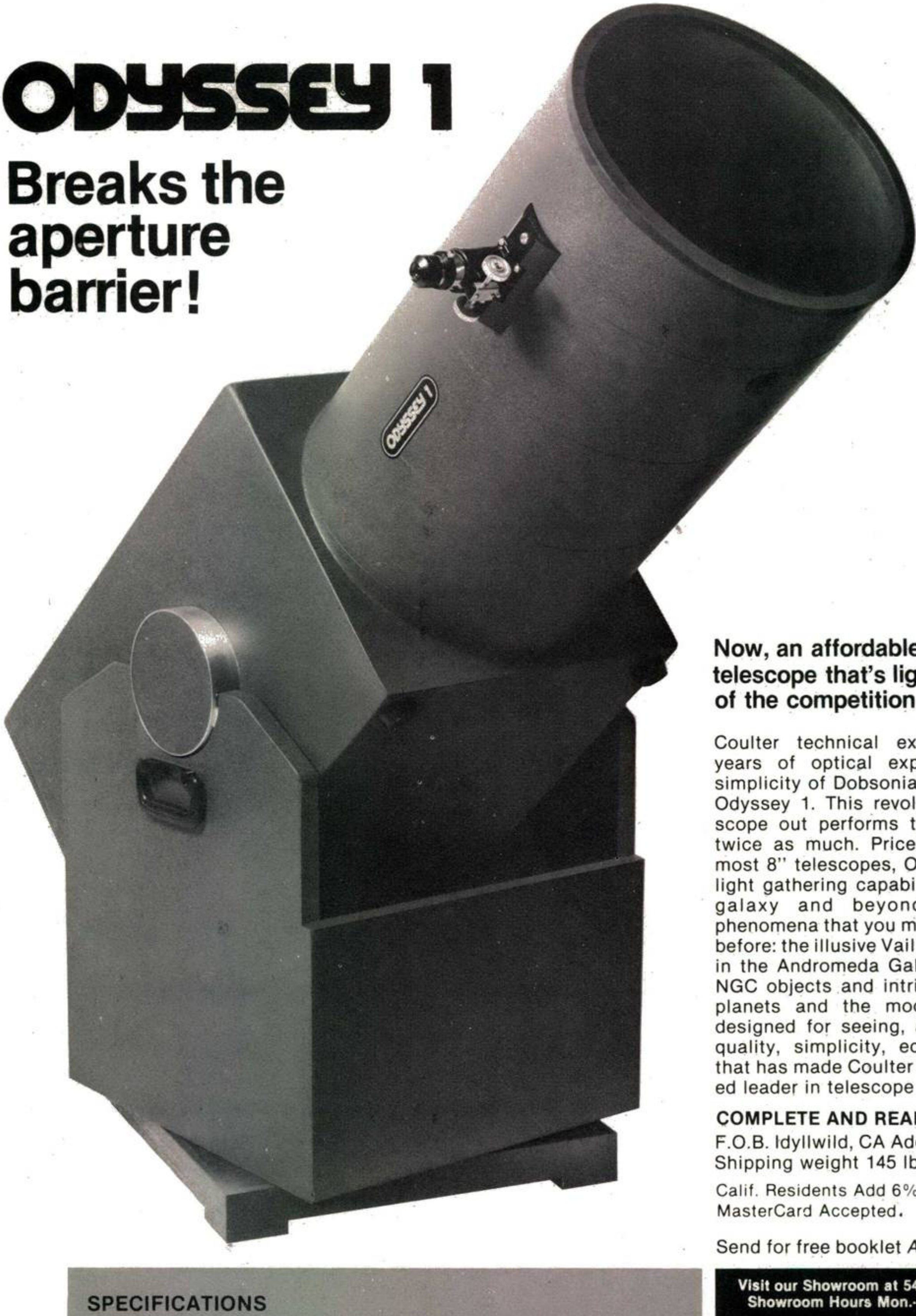

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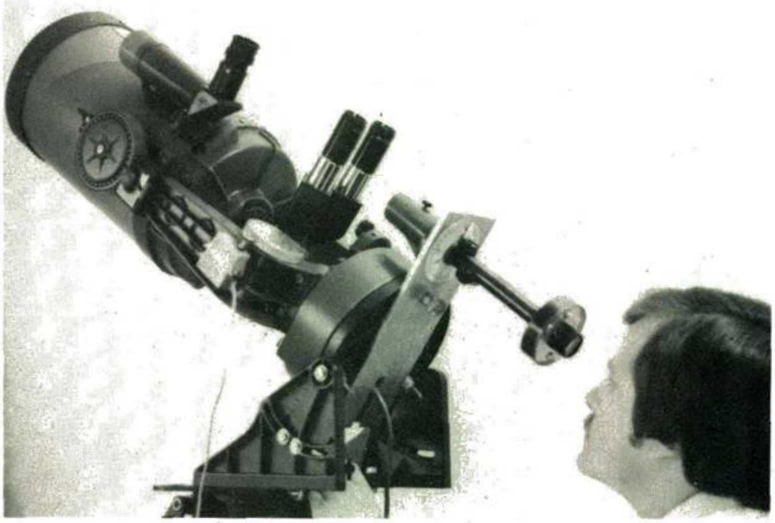

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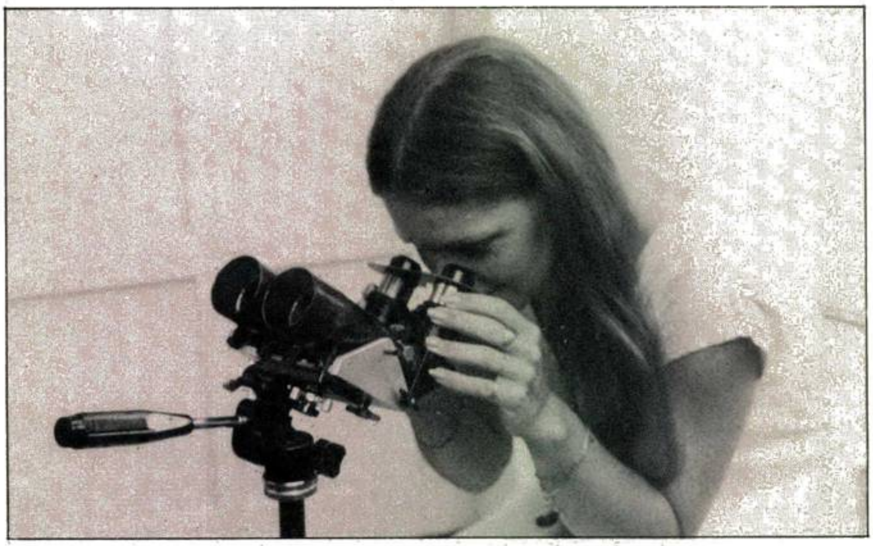

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ASTRONOMY
IN FOCUS

Fascinating Interpretations

Sirs / I find Mr. Ellenberger's method of refutation of the scientists quite fascinating. This fascination arises from the fact that he derides them for using interpretions of their data to refute Velikovsky. His arguments, however, are based on interpretations of interpretations of faulty or nonexistant facts. That Velikovsky's theories are still not proven (no matter how much he interprets and reinterprets) seems to be conveniently forgotten by Mr. Ellenberger.

And even if Oberg is wrong, does that make Velikovsky right? Ellenberger seems to be taking the easiest way out: he's taking everyone out of context. Surely his biased arguments can influence no one.

Robert Freese
Houston, TX

Colonize the Moon!

Sir / It is long past time all this rhetoric about "polluting" the Moon and other lifeless objects in the solar system was laid to rest. The Moon, magnificent as its desolation may be, is a slag heap. If men and women of vision and courage can reshape it into something useful to the human race, and in so doing reduce the environmental burden of industrial and mining activities on the terrestrial biosphere, then it would seem to me that those truly concerned with our environment would applaud them.

The choices are fairly clear: we can forsake technology, and condemn our children to a life of pain; we can continue to corrupt our environment until the Earth will no longer support life; or we can reach out to the energy and material resources of the solar system to create a space-based civilization capable of maintaining the Earth as a natural biological preserve. The choice is ours; the place to start is lunar and near-Earth space; the time is now.

Anthony M. Weiner
Findlay, OH

Where's the Sun?

Sir / Some time ago I learned that if there were inhabitants on the next closest star system (Alpha Centauri) they would see six stars in the constellation Cassiopeia, the sixth star, of course, being our Sun.

If this is true, I would like to know how that constellation would look from there; in other words, where would the Sun fit into the group?

Edward E. Ryczek
Milwaukee, WI

Mr. Ryczek / It's true the Sun would appear in the constellation of Cassiopeia as viewed from the Alpha Centauri system. Its position would be about 5° to the northeast of the Double Cluster in Perseus — the Sun would be just inside Cassiopeia near the Cassiopeia/Perseus border. It would appear as a 0.5 magnitude star (roughly as bright as Procyon).

It's simple to work out where the Sun would appear from a particular star: just add 12^h *of right ascension and change the sign of the star's declination. Of course, in dealing with stars more than a few light-years away, the background constellations are liable to shift and the foreground stars will confuse the picture, too. But so long as you don't push the technique too far, you'll be all right.*

Star Date

Sir / RE: The mention of "Star Date" in the November In Focus.

This program can also be heard on West Virginia public radio:

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Reception can be enhanced (at least here in Clarksburg) by connecting *Showtime*'s cable to an FM radio. Other TV cable systems should also aid reception.

National public radio stations elsewhere around the country may also carry the program at different times. NPR is a nationwide network present in most states, usually on FM, and usually near the extreme left end of the dial. The stations are often associated with universities.

Thomas Kenneth Reeves, Jr.
Clarksburg, WV

Pen Pal

Sir / I am writing to ask if any fellow astronomers in the States would like to exchange correspondence with me regarding astronomy in general and/or their work in any particular field. I am 26 years of age, and my interests are meteor observation and deep-sky objects. Of course, I have a general interest in just about anything to do with astronomy!

If anyone is interested, I would be delighted to hear from them.

Brian Jones
'Alcyone,'
28 High House Avenue,
Bradford,
West Yorkshire,
BD2 4ER,
England

Retinal Exposure

Sir / After reading the article "Four New Worlds" by David Morrison (September 1980), which I enjoyed very much, I came upon an interesting fact in the book *Stars and*

Telescopes by David P. Todd (Boston, 1901). In the chapter on the planets, surface detail on Io, Europa, Ganymede, and Callisto (as described by early planetary observers) is mentioned.

It states that "Professor W. H. Pickering at Arequipa, Peru, in 1892 and at Lowell Observatory in Arizona, 1894, has seen surface detail upon all the satellites except the second [Europa]...A white spot was seen several times near the north pole of IV [Callisto]." Could he have been seeing one of the large ghost impact basins (perhaps Valhalla) described in Morrison's article? If so, what an amazing feat of visual dexterity!

This brings me to a second point I would like to make. Although there appears to be a dramatic upswing in the number of astronomy fans interested more in photography than visual observations, there are still many of us who do little or no photography — at least I hope there are many of us left!

Although I truly enjoy looking at beautiful photos, I find drawings and visual descriptions immensely more satisfying. I realize that a photograph of Posidonius, say, (a personal favorite of mine) may be much more "scientific" than a drawing of it — but which is more beautiful or meaningful to the visual observer? You only need look at a few good drawings to realize that they show not only finer detail but are also a scientific art form in themselves.

Photography's fine, but I must admit that I observe primarily for the pleasure of visually observing the marvelous variety of objects in the sky!

Jim Phillips
Charleston, SC

Ooops

The eclipse labeled Jan. 4-5, 1992 on the map and Jan. 5 in the text of "North American Solar Eclipses" (November) will be visible from the Los Angeles area on January 4.

behind the scenes | odyssey grows

"Where do you keep Uly?" is the first thing that kids visiting our offices ask. ODYSSEY's editor Nancy Mack gives a conspiratorial grin: "Oh, he's out for an oil bath." They both know there's no robot editorial assistant at ODYSSEY magazine (What — no Uly?), but pretending is fun anyway.

ODYSSEY? What's ODYSSEY? We introduced it with a big series of ads in ASTRONOMY about two years ago. Remember ODYSSEY, a genuine astronomy magazine full of facts and interesting articles for kids of all ages (but mostly between ages 8 and 12)?

"Whatever *did* happen to ODYSSEY — your children's magazine?" people sometimes ask, aware that the mortality rate for new magazines is terribly high. "Did it fold?"

"Not at all," I'm pleased to answer; "it's alive and well — with a circulation of 40,000 bright kids. And now it's really beginning to grow by leaps and bounds." Then the clincher: "They've even added eight pages of Cadet Gazette news."

Ah, yes. Adding pages is the mark of success. They nod, glad to hear it. "Say, I've got a nephew who's nine. Umm, do you think he'd like it?"

Sure he would! And so might your niece, your son, your daughter, your grandchildren — or any bright child with an interest in space.

ODYSSEY has come of age. Though it's billed as a product of the AstroMedia Corporation, it's really the special "baby" of three hard-working people: Nancy Mack, the "crabby" Editor (known in the pages of ODYSSEY as TCE); Cathy C. Cook, the Art Director who spills vividly colored layouts through ODYSSEY's 40 pages; and Greg Walz-Chojnacki, the Assistant Editor who doubles in print as the robot Ulysses 4-11.

And of course, Robert, Dewey, and I make our appearance each month as "The Thoroughly Magnificent Richard and Robert Show," a rather zany science experiment.

Well, perhaps enough said. But, unless you don't know any kids at all, ODYSSEY ought to be of some interest to you, so I thought I'd tell you about it. And, if you don't know any kids at all, don't you wish somebody had been putting out a space, science, and astronomy magazine for kids when you were a kid?

Sincerely,

Richard Berry

Richard Berry
Editor

Astroscan Renewal Contest Winners

Every month, a lucky subscriber wins a FREE Astroscan telescope. To enter this contest, all you must do is renew your subscription within ten days of the arrival of your first renewal notice.

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In the future, watch for each month's winner at the beginning of AstroMart.

making astroprints

With your negatives thoroughly dry, the final step is turning those transparent little bits of acetate into magnificent, mouth-watering prints. Here goes!

I mentioned the equipment you need before, but let's run down the list again and check that you have all of it ready: enlarger, safelight(s), processing trays (three minimum), thermometer, chemicals (Kodak Dektol or equivalent, stop bath, fixer), photographic paper (of which, more later), dryer (rack, blotters, or electric), tongs (optional), easel (optional), contact printing glass (optional), focuser (optional), timer (optional), and paper towels (very useful). Additional items you may want are a papersafe and a chemical washing aid.

Wet & Dry, or May the Twain Never Meet

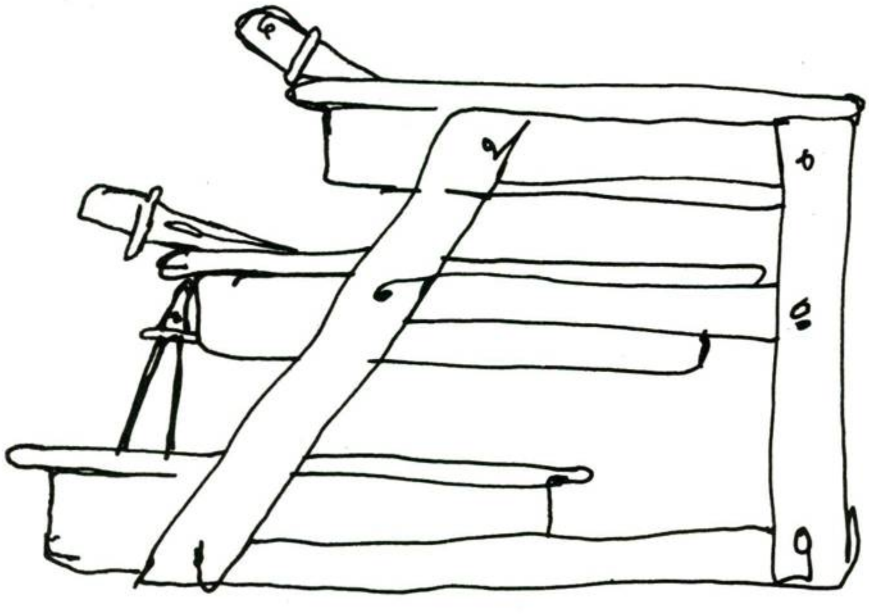
When arranging all this equipment on the countertop, good practice calls for separating it into a "wet" side and a "dry" side. It's inevitable that you'll slop some chemicals around, but negatives and photo paper must be protected from them. The answer lies in keeping the two functions apart.

On the dry side, place the enlarger, paper supplies, easel, focuser, and the negatives you intend to print from. On the wet side go the trays, tongs, and thermometer. The timer can go in the no-man's-land between; the drying rack should hang well away from everything else — even in another room. Hang one safelight over the trays, and another (perhaps smaller) near the enlarger.

Ideally you'd have two separate countertops, one each for wet and dry, but it's perfectly feasible to put both functions onto one. If you do this, remember to be scrupulously careful and keep the chemicals where they belong!

Of Papers, Diverse & Sundry

A trip to the photo store reveals a bewildering array of printing paper in every size, weight, contrast grade, and finish. To begin with, I suggest you get a small amount (25 or 50 sheets) of single weight, glossy finish, grade 3 paper in 4" x 5" or 5" x 7" size. This will start you off, and with experience you'll soon know just what you need and can then buy in larger quantities to reap some savings.

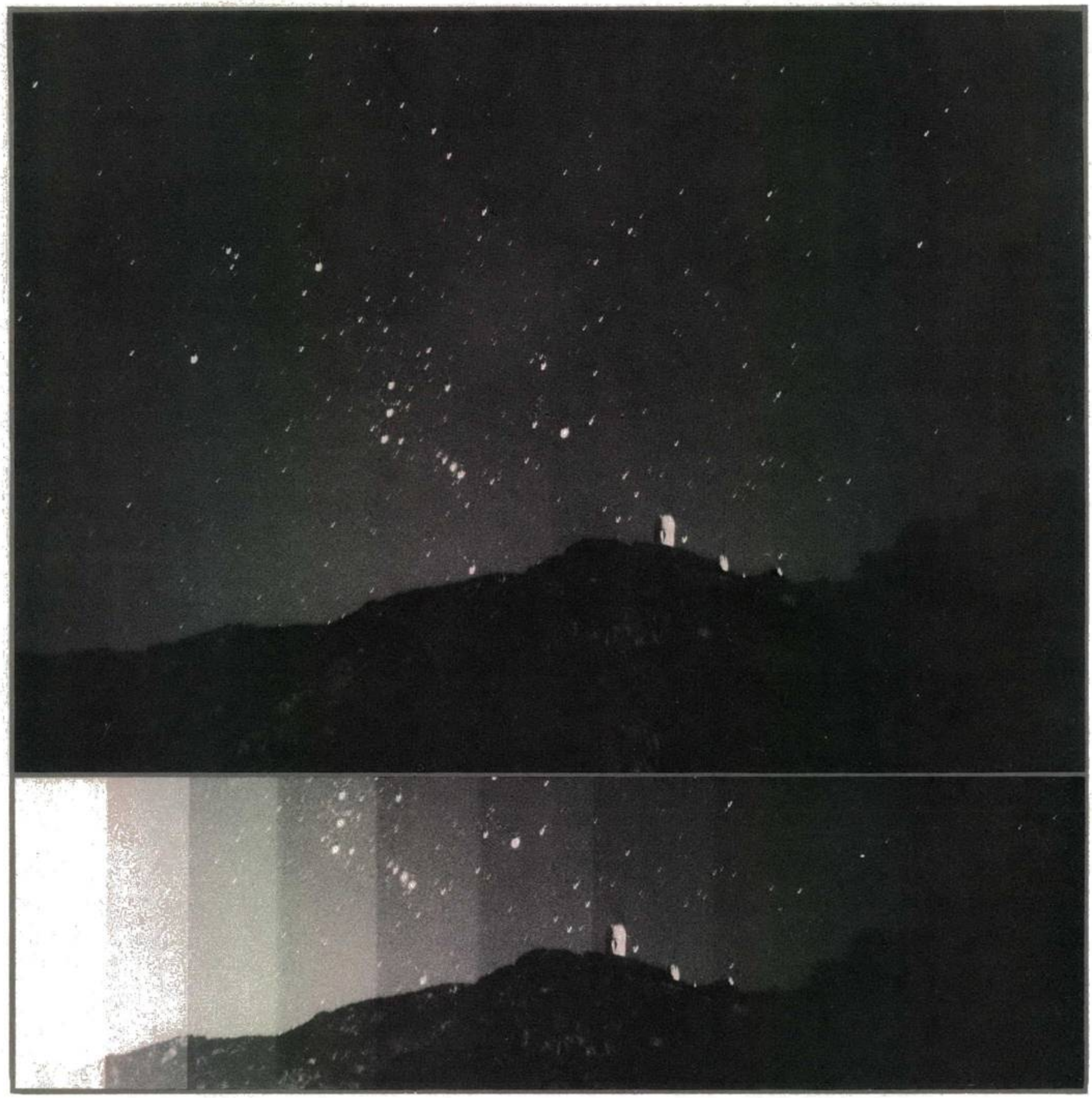


5 x 7 sounds small, but remember that few astronegatives can be enlarged much more than 8x, and 5x is more reasonable in most cases — especially beginning efforts. It's less expensive, too.

The question of "real" paper versus RC (resin-coated) is pretty moot. Some people swear by the RC papers; others swear at them. There's no question that processing — washing and drying — goes much faster with the RC papers, but there are some drawbacks. Should you leave them in the solutions too long, chemicals (chiefly fixer) can seep into the underlying paper base and become difficult (if not impossible) to wash out. The result would be a print that fades away in a few years. (Of course, improperly processed "real" paper prints will fade, too.) Also, RC papers must be handled with more care if you drymount them. Lastly, they cost more.

Choosing #3 grade paper amounts to a compromise. Grade 3 is a bit snappier than normal grade (#2) — which helps the usual low-contrast astronegative. On the other hand, the higher grades (#s 4 and 5) are very contrasty and using them effectively calls for a bit of practical experience in printing. (Give them a try later.)

Single weight papers are cheapest, double weight best if the print won't be mounted, and RC paper comes only in a medium weight having nearly the stiffness of double weight. Textured papers may allure, but use them only on your display prints. Those you make to submit to ASTRONOMY should be on glossy or smooth matte finishes only.



The first step in printing a negative is the "test print." Cover all but one end of the print paper, switch on the enlarger, and successively uncover strips of paper at 2 second intervals. Take the fully developed and fixed print and examine it for the most pleasing result — then reprint using that exposure. Photos by Richard Berry

Making a Print

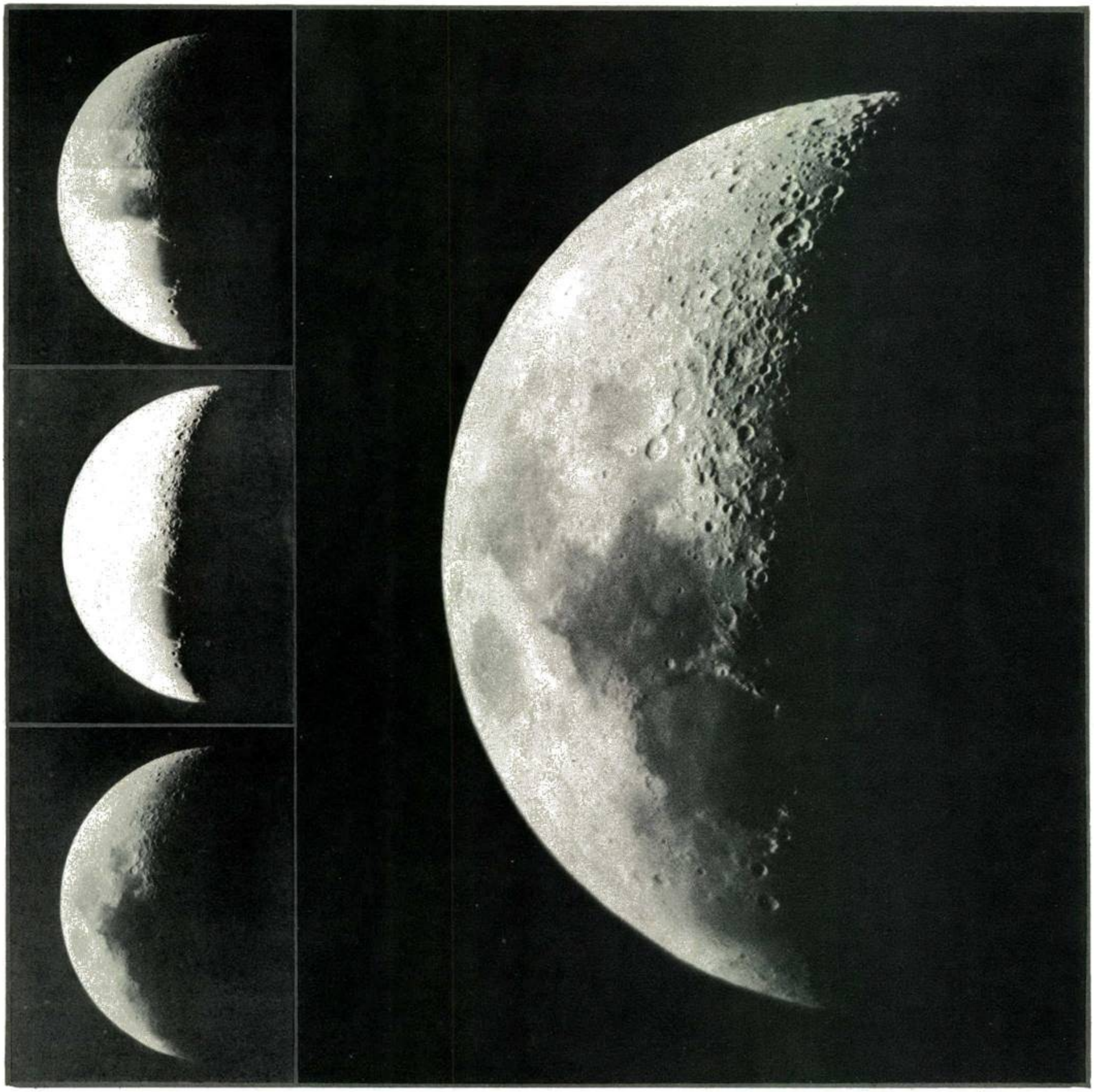
Begin your printmaking by arranging the trays in a row on the counter. (Newspaper under them will absorb drips. Use fresh newspaper each print session.) Whether you work left-to-right or the opposite, the developer tray comes first, followed by the stop bath and fixer trays. Label the trays indelibly on the outside as to contents and thereafter use only that solution in each. If you have tongs, mark one the "developer" tongs; the other will be used with both the stop and the fixer. (If you have three, then use one each for stop and fixer.) This prevents contamination and messed-up prints.

Next, prepare the chemicals in their trays. The working strength of Dektol paper developer is 1 part developer stock solution to 2 parts water. Mix enough working solution to cover the bottom of the tray ½" to 1" deep (this means a half-quart in an 8" x 10" tray). Don't use so little that it becomes exhausted halfway through the printing. Economy is o.k., but don't be stingy with the chemicals.

The stop bath is usually made up from ½ ounce of stock solution in a quart of water (32 ounces). This will comfortably fill an 8" x 10" tray.

The fixer gets used as mixed; pour out a sufficient amount. When you process ordinary paper for maximum lifetime, use two fixing baths in succession, discarding the first when it has processed about half its recommended limit. Advance the second fixer bath to become the first and pour a fresh second bath.

Dunk the thermometer into each tray (rinse it clean in between, of course!) and check that all solutions are within 5° F of each other and that all are around 65° F to 75° F. You may discover that you have to warm or chill a solution to bring it into this range; if so, pour the solution into a jar and immerse it in a hot or cold water bath



The Moon: make a test print (top left) to get the exposures for limb and terminator. At middle left is a "terminator" print showing a featureless limb; bottom left is a "limb" print with a too-dark terminator. Solution? Give the terminator its exposure, then cover it while you add exposure to the limb areas (right photo).

until it has the correct temperature, then pour it back into the tray.

Check the enlarger for dust, lay out the negatives you intend to print, and turn on the safelights. At this point turn the room lights off. Give your eyes a moment to adjust to the dim safelight and put the first negative into the enlarger. Turn it on and open the lens iris fully.

Projected on the baseboard, you'll see a grey, probably blurry image with lots of fuzzy black specks. Turn the focus knob until the image is sharp and adjust the negative in the holder until it's centered. Place the print easel, adjusted to your paper size, under the image.

You'll likely have to move the enlarger up and down on its post to get the image the right size on the easel; each height adjustment will necessitate a focus change — which in turn will change the size, and so on. . . . Eventually, you'll have a sharply focused negative framed on the easel the way you like it.

Close the lens aperture down to f/8 or 11. You'll notice the image gets darker and a close look will probably show it sharpened up in the corners. At this point, turn off the enlarger, remove a sheet of paper from its box or envelope and place it in the easel, being careful not to bump the easel out of place.

You can tell which side has the emulsion up by the way it curls. Ordinary paper curls *toward* the emulsion side, RC paper *away* from it (the RC emulsion side also feels slicker than the backside). Keep your fingers clean and touch the emulsion side only at the extreme edges.

Make a Test Print

Cover all but about an inch of the paper with an opaque sheet of cardboard and turn on the enlarger. At 2 second intervals, uncover the paper successively in one inch increments. When the last of it has been exposed, turn off the enlarger. The last strip uncovered will have received a 2 second exposure, the next a 4 second exposure and so on, with the first strip getting about 14 seconds. What you've just made is a test print.

Take the print over to the developer and slide it into the tray, face up. Using the developer tongs, push down any parts that stick up out of the "soup." Then gently rock the tray by picking up one corner a bit and setting it down. Go easy or developer will spill all over!

In a few seconds, the image will begin to appear. Let it develop fully. This means 2 to 2½ minutes with ordinary paper, about 60 to 90 seconds with RC paper. When the time's up, pick up the print with the developer tongs by one corner and let the excess solution drain back into the tray. Carefully slide the print into the stop bath tray, taking great care not to get any stop bath on the developer tongs. Pick up the stop and/or fixer tongs and make sure the print is completely immersed in the stop bath. Thirty seconds to a minute suffices here, then repeat the lift-by-the-corner maneuver, let drain, and put the print into the first fixer.

Swish the print in the fixer for about 3 minutes (ordinary paper) or 30 seconds (RC). Then check to see that the stock of unused paper is safely wrapped up and turn on the room lights.

Examine the print closely. Part of it will be very dark with few, if any, stars visible and part will be a light grey. The first sections you uncovered will be the darkest, for they had the most exposure. Knowing your intervals (2 seconds), count back and find the section with the most pleasing appearance. (If the whole thing is too dark, then you have given it too much exposure; close down the enlarger lens one or two stops and try again. If all of them were too light, open up a stop or two.)

Switch off the room lights again, put a fresh sheet in the easel, and use the best time to make a print. Develop it and fix it the same way as the test print. When it has been in the fixing baths for a total of 10 minutes (ordinary paper) or 5 minutes (RC), put it into the wash.

At this point you select a new negative and repeat the process. But this time, instead of wasting a whole sheet of paper on a test, cut a sheet into five 1" x 7" strips. Place one of these in the easel and use it as a test strip. Even this may be skipped once you get the hang of guessing just how much exposure a given negative needs, based on how bright it looks at f/8 or 11.

How to Become an Artful Dodger

O.K., the exposing and developing you've done up to now will work very well on negatives which have an average range of contrast in them. But supposing you took a photo of the Moon at First Quarter. When you make an ordinary print of it, you'll have either detail along the limb (and none along the too-dark terminator) or a magnificent and craggy terminator with featureless, white limb regions. Why can't you get *both* in one print?

The problem is that limb regions are far brighter than the terminator and the range of contrast between them is too much for the paper to handle. You could switch to a less contrasty, "softer" paper, but then you'd lose tone differentiation in the middle values — and the print would look muddy overall. The solution lies in giving the darker parts of the image more exposure.

Take a small piece of cardboard, cut out an irregular oval, and mount it with tape on a piece of coathanger wire about 6 inches long. Paint it flat black. Set up your Moon negative in the enlarger and make the short exposure to print the terminator details. Then use the cardboard on the wire to stop ("dodge") light from the terminator area and allow it to "burn" on into the limb regions. Keep the dodger moving a bit to blend the regions of different exposure or you'll get a hard, visible edge in the print. (How much extra exposure do you give? Make a test strip or proceed by trial and error.)

Another useful tool is a large sheet (11 x 14, say) of cardboard with a small hole cut in it. (Again, paint the entire thing flat black.) This tool lets you burn in just a little area and dodge most of the print.

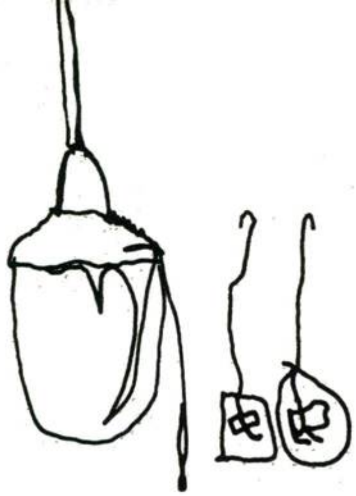
By mastering the knack of burning and dodging, you can make prints that record the outer regions of the Orion Nebula, say, and still preserve details near the Trapezium — an impossibly great brightness range by ordinary standards.

Washing and Drying

The last wet step in processing a print is removing residual fixer that would slowly (over years) destroy the image if it weren't washed out. Ordinary papers are relatively difficult to wash thoroughly because the paper stock absorbs chemicals into its fibers. With single weight papers, it's a good idea to wash in running water for an hour. You can shorten this time by using a so-called washing aid like Heico's Perma-Wash — a chemical that helps remove fixer by increasing its water-solubility.

RC papers, since their paper base is virtually sealed away, take less time in the wash — fixer has to be removed only from the emulsion itself. With these, a 15 minute wash is plenty.

A number of print washers are available on the market, but you can make a fine one from a plastic dishpan. Buy one big enough to hold your largest prints and with an awl, punch a few small holes in the pan's sides along the bottom edge. (Fixer-laden water is denser than tap water, so the drainage must be at the bottom.) Run water into the pan at the rate you'll wash the prints with. When the pan stays comfortably full (all prints well covered), then you have enough holes. But add any holes *carefully*.



Another method, good where water must be conserved, uses repeated soaking baths, interspersed with quick rinses. Rinse off the prints when they come from the fixer, then place them into a bath of water for 5 minutes, while you shuffle through them. At the end of the time, pour off the water, rinse the prints again, and put them into a fresh bath. A total of 10 changes of water will wash paper prints adequately; use four changes with RC papers.

When the washing is done, the prints must be dried. Back in the first article, I mentioned a neat drying rack you can make from a length (say 10') of 3' wide nylon screening and two wood slats. This "hammock" can be rolled up when not in use and the nylon's impermeability prevents chemical residues from building up and contaminating later prints — any residue or dust can be scrubbed off.

Of course, blotters are perfectly feasible, and someone in a hurry will appreciate the speed of an electric dryer. But both of these are potential chemical contaminators: periodically the blotters will need to be replaced and the cloths of the electric dryers removed and scrubbed.

Remove your completely washed prints from the washer and squeegee them gently on a hard smooth surface. Place ordinary paper prints on the hammock drying rack face down. (This will minimize their curling.) Place RC prints face up.

When the prints are dry, it's a good idea to make notes on the back labeling the subject, the date, and time it was taken as well as film, exposure, and telescope details. If you send prints to ASTRONOMY, include your name and address on each, too.

— *Robert Burnham*

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Topical Index

The following is a listing of feature articles devoted primarily to subjects of strong interest to our readers. There may be some duplication, but each has a different viewpoint. All are 4 - 24 pages long and most are heavily illustrated.

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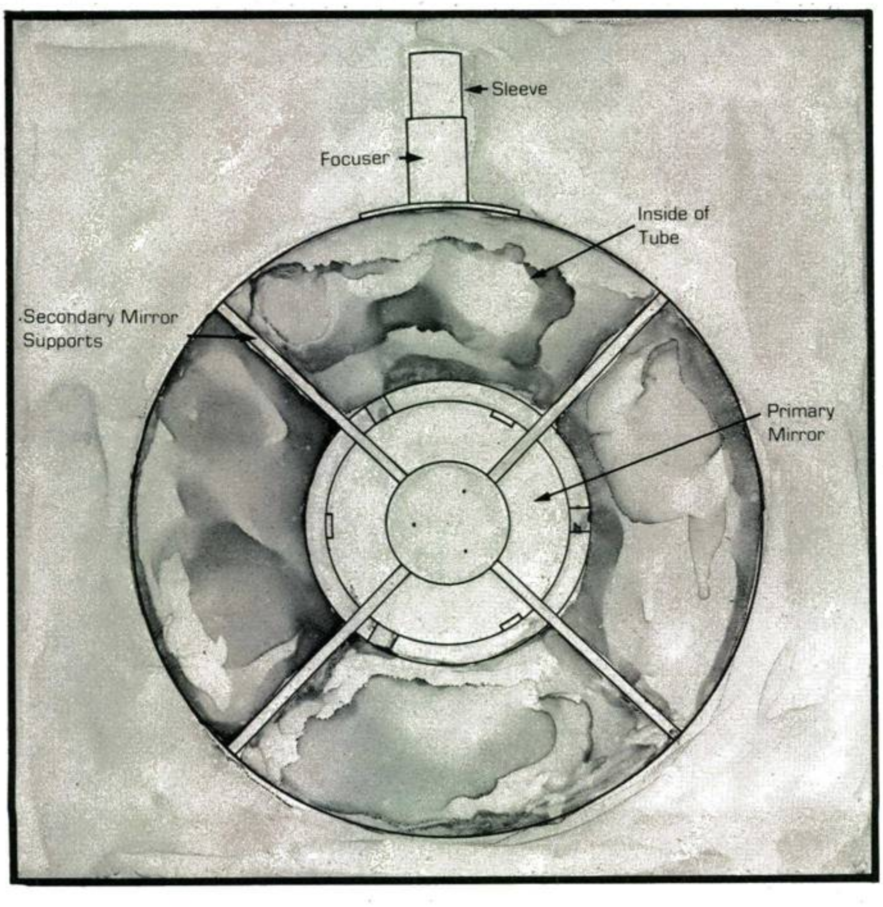
equipment atlas

collimating your telescope

Let's face it, the prospect of collimating a reflecting telescope frightens the daylights out of most beginning telescope owners (and probably helps sell at least a few refractors to boot). And because they aren't always properly aligned, it's a safe bet that there are a lot of reflectors around giving views that range from "okay" to "so-so" to "downright crummy." What's more, unbelievable numbers of people are tolerating these poor images — which a few minutes of careful adjustment would correct — simply because they're afraid to fiddle with their telescopes. Now if that sounds familiar. . .

How do you know when your scope's collimation is off? Easy: look for star images with little flares splayed out to one side all across the field of view. Or look for images that never come to a crisp focus no matter how you rack the eyepiece in or out. Another bad sign is when double star images all smoosh together in a blur and planetary details (especially the Moon) retain a fuzziness even on nights of superbly tranquil seeing.

Since there just isn't any need to put up with views any poorer than the best your scope can provide, let's see how to tweak up your optics for top performance.



The Common Newtonian

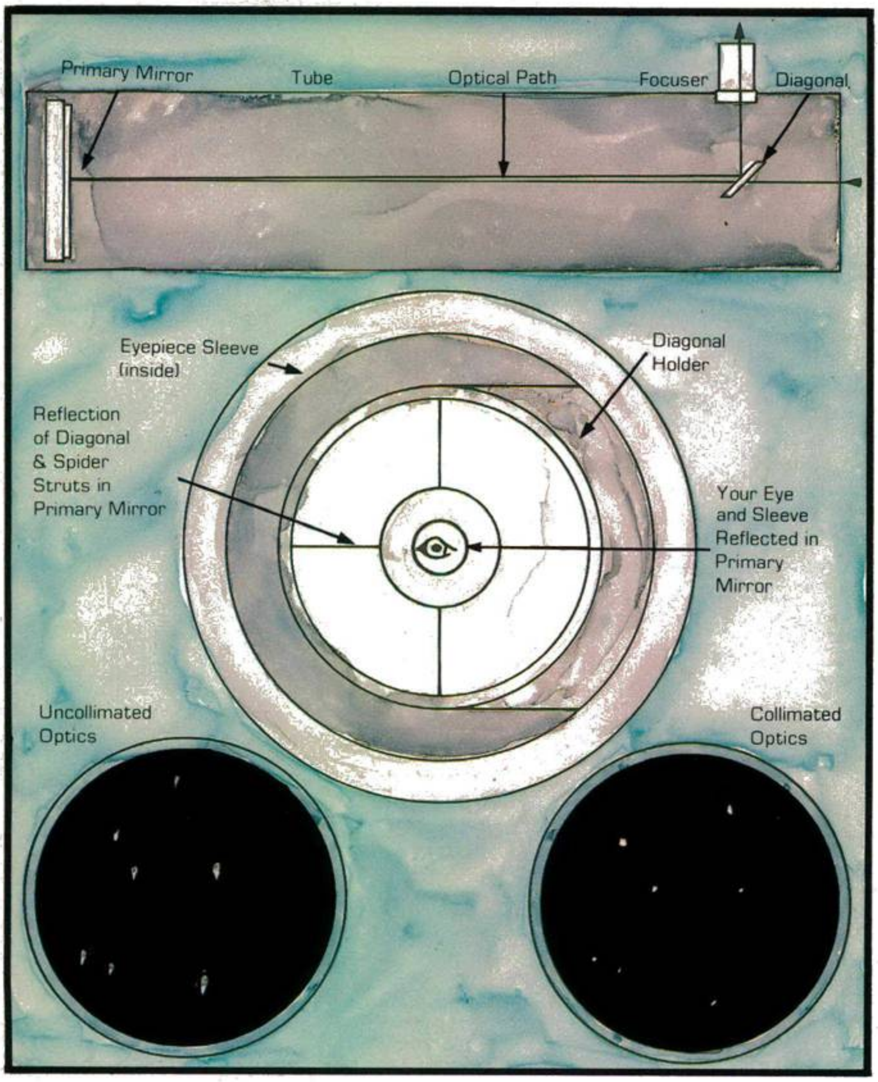
Newtonians are probably the most popular design of telescope — there are thousands of them in use every clear night. Collimating one is a cinch, especially when it has an f/ratio greater than f/6.

Rough collimation amounts to little more than removing the eyepiece from its holder, looking in, and adjusting things so that all the mirrors lie concentric. That's really all there is to it. (Fine collimation requires a star-test, but is also very simple.)

To start with, point the telescope tube (in its mount or not) at a light-colored surface or the daytime sky. Remove the eyepiece from the holder and rack in the sleeve all the way. Put your eye up close and look in. Reflected in the diagonal, you'll see the whole primary mirror. In the primary will be an image of the diagonal, its spider supports, and your eye looking down the sleeve of the eyepiece holder. If all are perfectly concentric, your scope is at least roughly well-collimated and you can skip ahead to the star-test outdoors. If they aren't concentric, here's how to make 'em that way:

Start by constructing a sighting device to help your eye look straight in. Take one of those plastic canisters that come with Kodak 35 mm film. Cut the bottom off and in the center of the grey plastic cap punch a small hole, about three or four millimeters in diameter. Snap the cap back on the canister and slip it into the sleeve of the eyepiece holder. Now when you peer in, your eye is nicely centered.

Next align the diagonal. To do this, look into the sleeve and check that the entire mirror surface of the diagonal can be seen. If it can't, your eyepieces aren't catching all the light they should from the primary. Adjust the diagonal support until the secondary mirror is



lined up with the eyepiece tube.

Now examine the image of the primary to see if it lies centered in the diagonal. No part of it should extend off the diagonal's mirror surface. It's important that you don't move your eye around while doing this — that's the "why" of the sighting device. If the primary isn't concentrically placed, adjust one or more of the three little screws on the upper part of the diagonal holder where it joins the spider. Trial and error will rapidly show you which one(s) you should move and how much. But go very slowly — you'll be surprised how little movement will do the trick.

The last rough adjustment is to center the reflection of the diagonal and spider vanes in the primary. There are three screws (some scopes use wing-nuts) at the back of the mirror cell. Tighten or loosen them gently and observe the result. You'll notice that the image of the secondary moves away from the nut you tighten. Center the diagonal's image as best you can.

On the next clear night, take the scope outside, give it time to cool down, and aim it at a medium bright star — one of Orion's Belt stars, say. Put in a high-power eyepiece, throw the image a little out of focus, and examine the result. You should see a shadow of the diagonal holder and spider vanes superimposed on several concentric rings of light. If everything is perfectly adjusted, the rings and shadow will be concentric. If they aren't (and this is usually the case), fiddle with the primary mirror screws as you did before until the rings surround the shadow neatly. Upon focusing sharply, star images should now be perfect — a tiny round Airy disk with one or two faint diffraction rings. If they show any flare or tail to one side, adjust the primary mirror screws a little more until the flare goes away.

The Fast Newtonian

Fast Newtonians (f/ratio less than f/6) require more precise centering than the simple procedure listed above will achieve. Here's what to do:

Start by locating the center of your primary mirror by careful measurement with a ruler. Place a small, neat spot of enamel paint or india ink (5 mm maximum size) at the center and set the mirror aside to dry. Next, take the diagonal mirror and find its center by measurement as well. Offset its alignment spot toward the near (eyepiece) side of the diagonal by a small distance (see table on p. 57). Having checked and measured *carefully*, place a tiny dot of ink or paint about a half millimeter in diameter in the proper place. (A technical pen — such as Koh-i-Noor or Faber-Castell — with india ink will mark a mirror very neatly.)

Outrageous? A desecration? Sure sounds like it! But bear in mind that the center of the primary lies in the shadow of the secondary and thus contributes no light to the image. And correspondingly, the image of the primary's "blind spot" falls in the center of the secondary so you aren't doing any damage there, either.

For the next step, place your sighting tube (see box) in the eyepiece holder. Peek in and move the diagonal forward, backward, or side-to-side until its little black spot lies at the center of the sight tube's cross hairs. Next, adjust the tilt screws on the diagonal until the spot on the primary mirror falls behind the cross hairs. Then adjust the primary until the image of the sight tube's cross hairs (reflected in the primary mirror) also lies coincident with the cross hairs. This completes the rough alignment; finish off with a star-check like that already described.

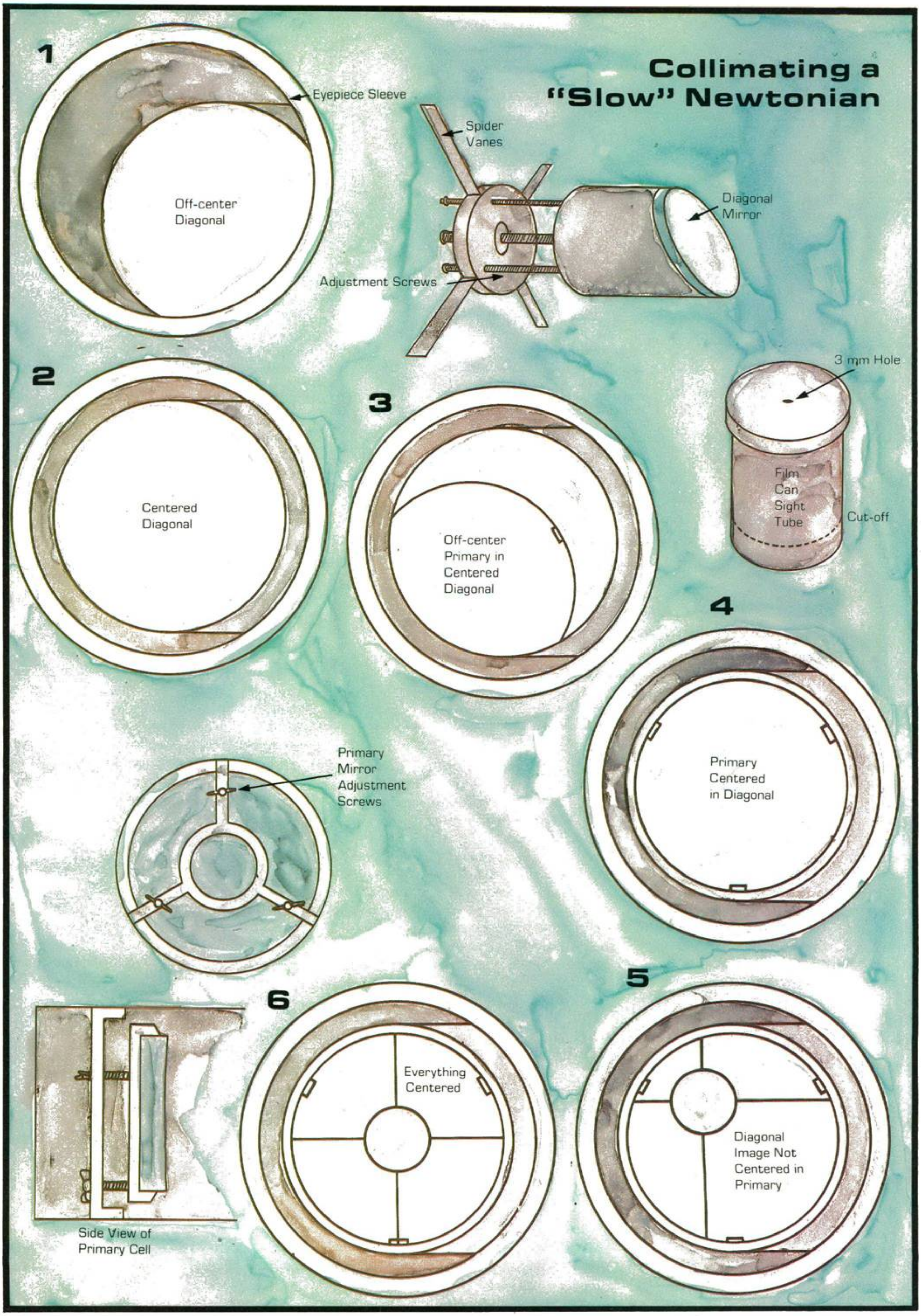
Once you've made your sighting tube and marked the mirrors, the actual time spent in aligning them will be very short. You set up, insert the sighting tube, look in, and make any adjustment needed. If your optics are well-mounted, only the roughest handling — like bouncing down some corduroy backroad to a dark-sky site — will jiggle the alignment away from

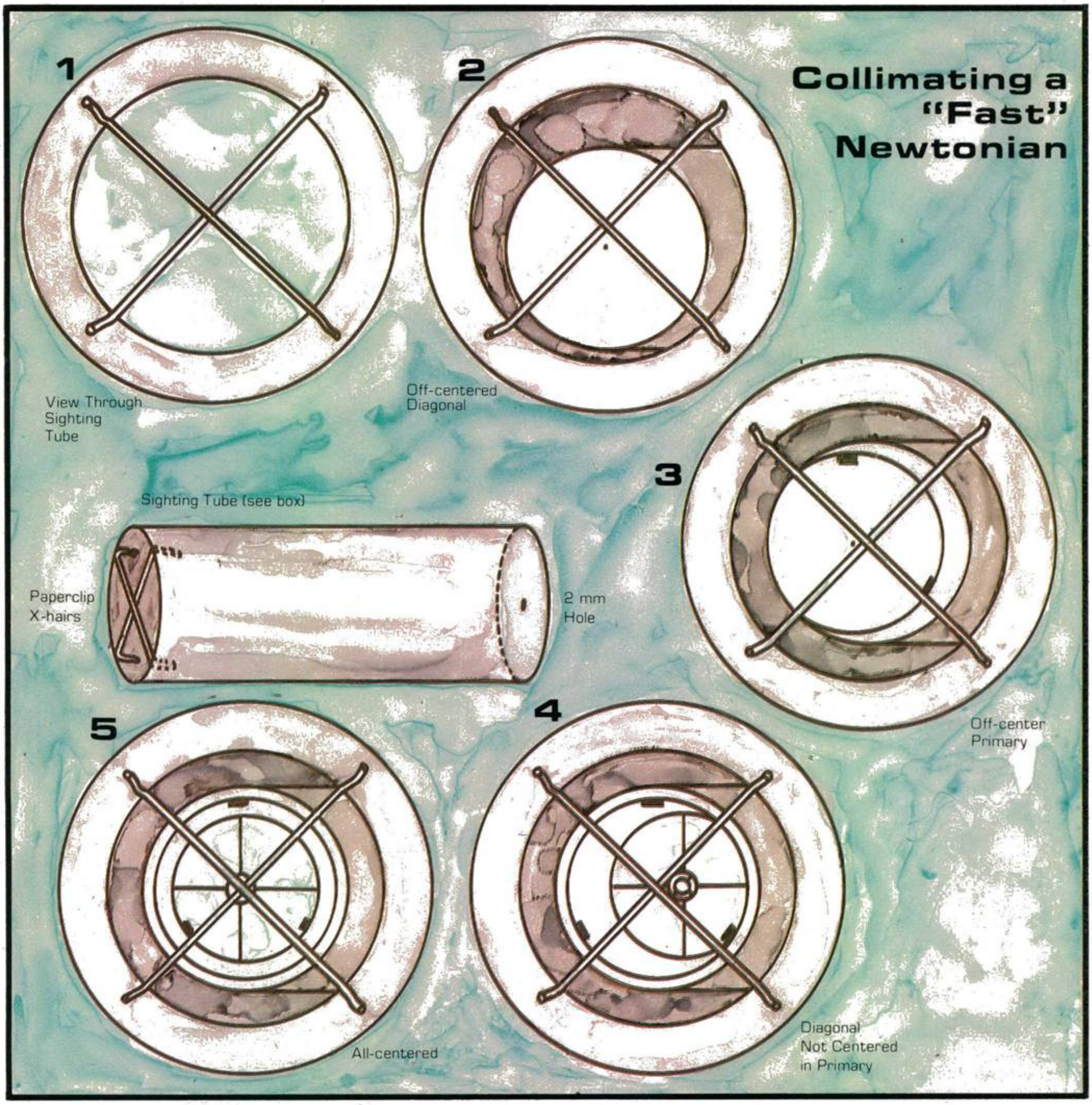
the sighting tube

The sight tube for collimating a fast Newtonian has an outside diameter of 1¼″ (or 2″ if you have the large diameter focuser) and a length of 6″ to 8″. It must fit snugly into the eyepiece holder, yet not so tight that it sticks. Make it out of a metal tube, if possible, or rolled Kraft or Manila paper.

Plug one end with a cap having a carefully centered 2 mm diameter hole. Across the other end, place two cross wires. Paper clips held in place with glue work quite well. Since it's very important that the intersection of the cross hairs lies exactly at the center of the tube, center it by rotating the tube in a vee-block jig (of wood, cardboard, or whatever) while you peer in through the 2 mm hole (see diagram page 57).

Collimating a "Slow" Newtonian


1
Eyepiece Sleeve
Off-center Diagonal
Spider Vanes
Diagonal Mirror
Adjustment Screws
2
Centered Diagonal
3
Off-center Primary in Centered Diagonal
3 mm Hole
Film Can Sight Tube
Cut-off
4
Primary Centered in Diagonal
Primary Mirror Adjustment Screws
Side View of Primary Cell
6
Everything Centered
5
Diagonal Image Not Centered in Primary


Collimating a "Fast" Newtonian
1
2
View Through Sighting Tube
Off-centered Diagonal
3
Sighting Tube (see box)
Paperclip X-hairs
2 mm Hole
5
4
Off-center Primary
All-centered
Diagonal Not Centered in Primary

perfection.

Schmidt-Cassegrains & Refractors

The optical system of a Schmidt-Cassegrain is extremely sensitive to adjustment. Accordingly, manufacturers lock in the alignment of the primary and corrector plate at the factory; the sole adjustments left to the owner are with the secondary. The various makes available all differ slightly in detail and come with owner's manuals having specific instructions. Follow the directions in yours.

With refractors, the watchword is *Don't*! Fooling around with one is a risky, tedious business with no guarantee of success. It's very unlikely that you'll ever need to make an adjustment to the common, everyday refractor. Larger instruments — which often do have provision for adjustment — usually belong to institutions; they should have it checked by an optical technician if problems occur.

Above all with little refractors, stalwartly resist the temptation to take the lens cell apart, since you'll likely destroy a carefully-done factory collimation job.

— *Robert Burnham & Richard Berry*

offsetting the diagonal's center spot

mirror diameter	f/4	f/5	f/6	f/7	f/8
6 inch	0.21	0.14	0.10	0.08	0.06
8 inch	0.24	0.16	0.11	0.09	0.07
10 inch	0.27	0.18	0.13	0.10	0.08
12 inch	0.29	0.19	0.14	0.10	0.08
14 inch	0.31	0.21	0.15	0.11	0.09
17½ inch	0.36	0.23	0.17	0.13	0.10

(all dimensions are in inches)

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United States May Miss Halley's Comet

When the orbit of Halley's Comet brings it near the Earth in 1986, scientists around the world will be monitoring it closely with highly technical instrumentation sent into space. Researchers in Japan, the Soviet Union, and several European countries are already planning a number of deep-space missions — but one major power won't be there for the rendezvous: the United States.

Scientists across the country are concerned that U.S. scientists will miss this opportunity to study the famous comet, whose visits to the Earth every 76 years have been documented since 240 B.C. Calculations have identified it with a large comet seen during the Norman Conquest of England in 1066 which was illustrated in the Bayeux Tapestry. The comet greeted Mark Twain at his birth in 1835, and said goodbye when it appeared in 1910 at the time of the author's death.

"The National Aeronautics and Space Administration (NASA) has a comet rendezvous mission under consideration, but current budgetary difficulties in the U.S. make it unlikely that this mission will be approved," said Dr. Duwayne Anderson, a consultant with the Jet Propulsion Laboratory (JPL) and a faculty dean at the State University of New York at Buffalo. "This is a matter of great concern to the scientific community involved in space research," he added.

A mission sponsored by the European Space Agency is designed to observe the nucleus of the comet during a brief flyby. The European mission has been dubbed Giotto, in honor of the 14th century Italian painter who depicted Halley's Comet in one of his paintings. The Japanese mission, known as Planet A, will carry a camera and instruments to record the spectra of the coma and tail and any magnetic fields. Not much is known about the Soviet mission, but scientists believe that it may involve a flyby of Venus in such a way as to make a rendezvous with Halley's Comet possible.

A rendezvous rather than a flyby is difficult because the comet is in a retrograde orbit, circling the Sun in the opposite direction from Earth and the other planets. An early American proposal for a rendezvous mission involving the use of a solar sail was scrapped because of its high cost, and a later proposal for a flyby of Halley's Comet coupled with a rendezvous with another comet several years later failed to gain budgetary approval last year. And now an American mission of *any* sort is in serious doubt.

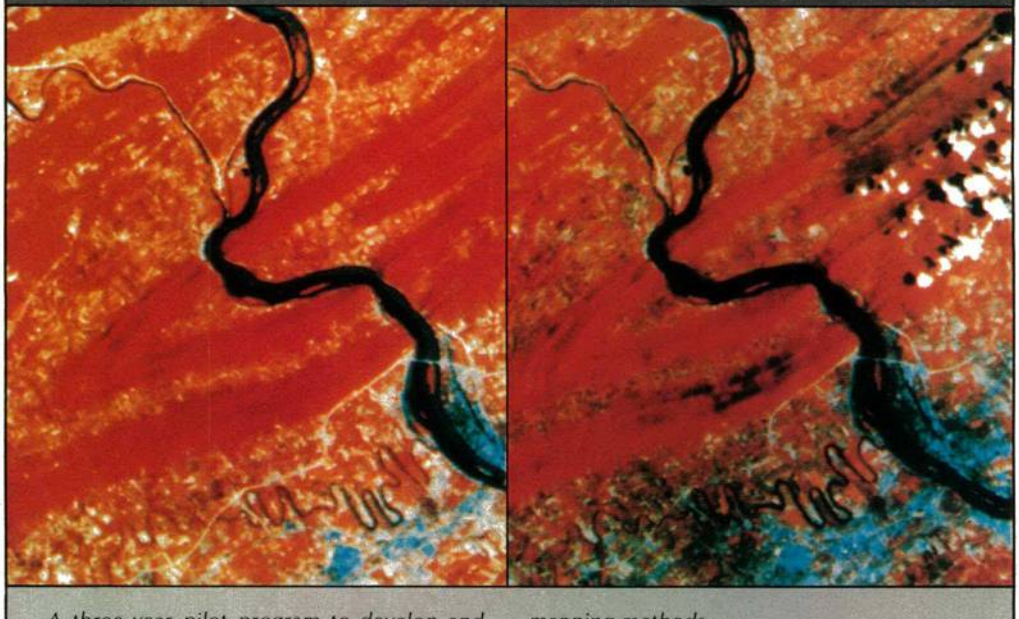
"The Americans will be the only major scientific community in the world not to 'show up' at Halley's Comet," noted Dr. Fraser Fanale of JPL and the University of Hawaii. "Most of the other countries will perceive this as evidence that the U.S. cannot do it, or at least as a loss of will on the part of our technological community. This will be bad, a real turning point for the U.S."

Funding must be approved in the next fiscal year's budget if the U.S. is to launch a "reasonable" scientific expedition to meet the comet, Fanale added.

Everett Gibson of the Lyndon B. Johnson Spacecraft Center in Houston, Texas, explained that a rendezvous with Halley's Comet means more than just a loss of face to U.S. scientists.

"We need to understand the realm we live in, how we

Landsat Watches Gypsy Moths



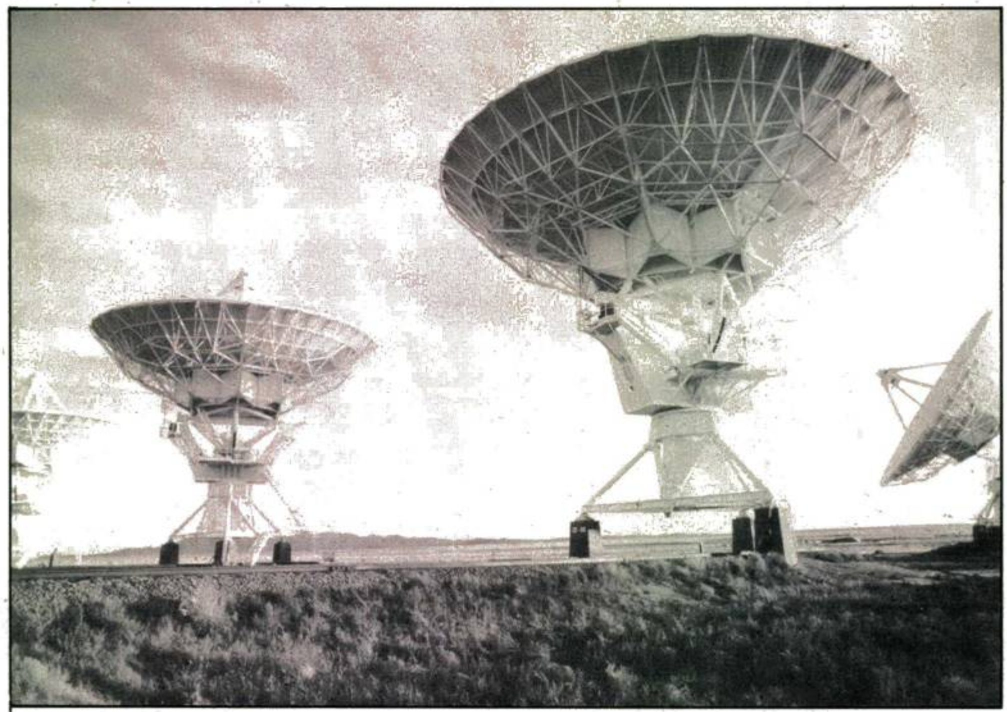
A three-year pilot program to develop and demonstrate the capability of using Landsat satellite data to detect and monitor gypsy moth damage in Pennsylvania forests has been started by NASA and the Pennsylvania Department of Environmental Resources.

The gypsy moth caterpillar, which primarily inhabits the northeastern United States, feeds predominantly on the leaves of hardwood trees, such as oak and maple. In 1980 alone, the caterpillars defoliated 440,000 acres of hardwood forests in Pennsylvania. Over the past 10 years, gypsy moth damage to the hardwood forests of Pennsylvania has been estimated at $32,000,000.

By updating the satellite imagery, foresters will be able to identify which forested areas are infested, as well as which areas to isolate for pest management activities. These satellite monitoring techniques should be a significant improvement on conventional aerial sketch mapping methods.

During the program, the Landsat imagery will also be used to generate a mosaic of the entire Keystone State. Each Landsat image covers an area 300 kilometers (115 miles) square.

The above photos, taken in earlier tests, show the damage created by the moths to forested areas (which show up in the images as bright red) around Harrisburg, PA. The photo on the left was taken in the summer of 1976, and the one on the right one year later. The brownish area along the ridge at the top right hand corner of the 1977 image indicates the extent of damage. Another area near the center of the same picture on the right is darkened and shows where the moths have defoliated an area west of the river. Both these areas show healthy vegetation (bright red) in the 1976 image on the left. NASA photographs.



These 82-foot diameter antennas are part of the 27-antenna contingent forming the Very Large Array— the most powerful and sensitive radio telescope in existence. Photo courtesy of E-Systems, Inc.

evolved," he said. "We've learned more about the Earth by studying lunar rocks obtained from our manned missions to the Moon than we had previously. We obtained a radiation history of the Earth from the lunar rocks."

Gibson, who was on the research team that analyzed soil samples taken from the Moon by the Apollo 16 spacecraft, added that the scientists believed that they found remnants of a comet which had crashed against the Moon among the samples.

He also explained that scientists now believe the Earth has been hit by a "piece" of a comet which caused great devastation in an isolated northern area of Russia in the early part of this century. Trees were felled for miles in the gigantic Tunguska explosion which, strangely, left no remnants for analysis. "Unfortunately, with the state of world politics today, such a gigantic, unexplained explosion might be interpreted by nervous world leaders as the unleasing of an atomic weapon," Gibson said. This is another reason why scientists want to learn as much as possible about the orbits and composition of these unique heavenly bodies.

"The nucleus of a comet is, we believe, made up of frozen ices with silicate matter dispersed," Gibson explained, "while the tail is made up of these icy particles blown back from the nucleus by the solar wind."

Ironically, the U.S. space community is being left out of a Halley's Comet rendezvous at a time when one of its most exciting achievements — the Voyager mission — is sending back to Earth the "most spectacular pictures ever seen" of Saturn and her rings. Voyager 1 flew by Saturn last November 12, and Voyager 2 is scheduled to arrive there in August.

"Many people think the space program is going full strength because in the last few years we have seen the results of the probes to Venus, Jupiter, and Saturn," Gibson commented, "but these programs actually started a decade ago. At present, there is only one program approved by Congress in the planning stages; after that — nothing. Things will be bleak for a long time," he said.

Steven Squyres is just completing his Ph.D. at Cornell University, where Carl Sagan is a member of his graduate committee. He is especially disappointed about the bleak future that space exploration seems to face. "The exploration of space is probably the most important thing scientists are doing now," he feels. "We are explorers in the same sense as Columbus was."

He added that while young people seem excited about the prospects of space exploration, their parents are not. "The political motivation is not there," he said.

His colleagues agreed. "Every great nation in history was going out and exploring new worlds at its peak," Gibson noted. "When the goal of discovery stopped, the nations started their decline."

Fanale cited a speech that noted author James Michener made at last year's annual meeting of the American Astronomical Society, in which he said the backing off of America's national instinct to "reach out and explore our setting may be symptomatic of the approach of an intellectual mini-Dark Age which will have worldwide implications."

"The space program's budget is only one-tenth of one percent of the national budget," Fanale pointed out. "But this research is important not only from the scientific perspective, but also for the inspirational value to ourselves as a nation and as a world."

Gibson concurred, adding, "We gained a lot of understanding of the Earth in our previous missions. The notion that we are alone and unique in the solar system came when we got off the Earth, looked back, and saw that we have to take care of our planet."

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VLA Open for Business

The world's largest radio telescope, a giant instrument that may revolutionize radio astronomy with bold new concepts and give researchers a major tool for seeking answers to puzzling questions about the universe, was brought into full operation last October in the isolated Plains of San Augustin about 50 miles west of Socorro, New Mexico.

Called the Very Large Array (VLA), the instrument is a unique system of 27 dish antennas which will use the Earth's rotation to sweep the sky to the edges of the observable universe. It will give astronomers information on such enigmas as black holes, the super-energetic objects called quasars, galaxies, and the nature of molecules and other matter in the vast reaches between the stars which not long ago were thought to be empty space.

A small group of scientists, technicians, and local, state, and federal government officials was on hand to mark the scientific milestone

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climaxing years of effort which started in 1961 when astronomers first expressed the need for a large radio telescope and the VLA concept was born.

Construction was started on the $78 million telescope on December 4, 1972, just four months after the President signed into law an appropriations bill providing initial funding for the project. The VLA was constructed within the budgeted amount and went into full operation on schedule.

In the past, radio astronomers, dealing with radiation of much longer wavelengths than those of light, produced maps of radio sources which were much fuzzier than the photographs of optical astronomers. But with its special configuration on the remote high-altitude plateau, the VLA can produce a "radio picture" of a celestial object with the clarity of the finest photographs taken by the world's largest optical telescopes. At its full extension, the VLA gives scientists the same resolution they would get if they used a single radio telescope with a diameter of 21 miles. Its 27 antennas give the VLA a combined collecting area equal to that of a single antenna 430 feet in diameter.

The VLA's 27 steerable telescopes — each 82 feet in diameter and weighing 210 tons — are distributed along three arms consisting of double railroad tracks in the shape of a Y. Three 120° angles separate the arms, two of which are 13 miles long and the third 11.8 miles. A special 36-wheel transporter moves each antenna to one of 72 observation stations, giving scientists a choice of looking at a small point or a wide area of the sky. In general, however, the same configuration is used for intervals of several months.

The VLA gets its extraordinary power through use of a technique called aperture synthesis which revolutionized radio astronomy when it was first introduced in the 1950s (see "Using Earth as a Radio Telescope," ASTRONOMY, October 1979). Aperture synthesis is a technique in which radio signals received from several small telescopes are combined in such a manner as to give a resolution that would be obtained by a single, much larger telescope. During the observations the Earth's rotation continuously alters the VLA's perspective of a radio source. Scientists arrived at the Y shape of the array after extensive design studies to optimize the performance of the telescope over the entire sky.

Because of its design, rather than being a single 27-antenna instrument, the VLA actually operates as 351 two-antenna combinations called interferometers. To collect, correlate, and store the billions of pieces of information obtained by these combinations requires extremely sophisticated electronic instrumentation. Some of the complicated data handling is done in times as short as 10 billionths of a second.

The VLA was constructed in the remnant of an ancient lake bed where there were only a few ranches and scattered herds of cattle grazing on thin clusters of grass and sage. The site was selected because it has certain important requirements and at the same time is as close to the equator as possible in the continental United States, enabling the instrument to scan a large portion of the sky. The location's low humidity and high altitude — 7,000 feet above sea level — also help assure good radio reception from the skies. With a total difference in elevation of only about three percent between the ends of the three rail lines, it is easy to move the telescopes from station to station at a top speed of five miles an hour.

Since it began gathering data in October 1975, approximately 300 scientists from 84 institutions in 27 states and 13 foreign countries have been attracted to the VLA. The instrument is in nearly continuous use — 24 hours a day, seven days a week — stopping only for maintenance. Unlike optical telescopes, the VLA is not limited to nighttime observations nor by normal cloud cover. Only on Thanksgiving, Christmas, and New Year's Day does the VLA stop scanning the heavens.

The early operation of telescopes — both radio and optical — has been likened to the "shakedown cruise" of a new ship when operators must become familiar with the characteristics and eccentricities of their equipment. The VLA is still in this phase, but even after the "shakedown" has ended, the instrument will be in a continuous state of adjustment and improvement as astronomers try to take advantage of the VLA's versatility to get more and better observations.

Jovian Life?

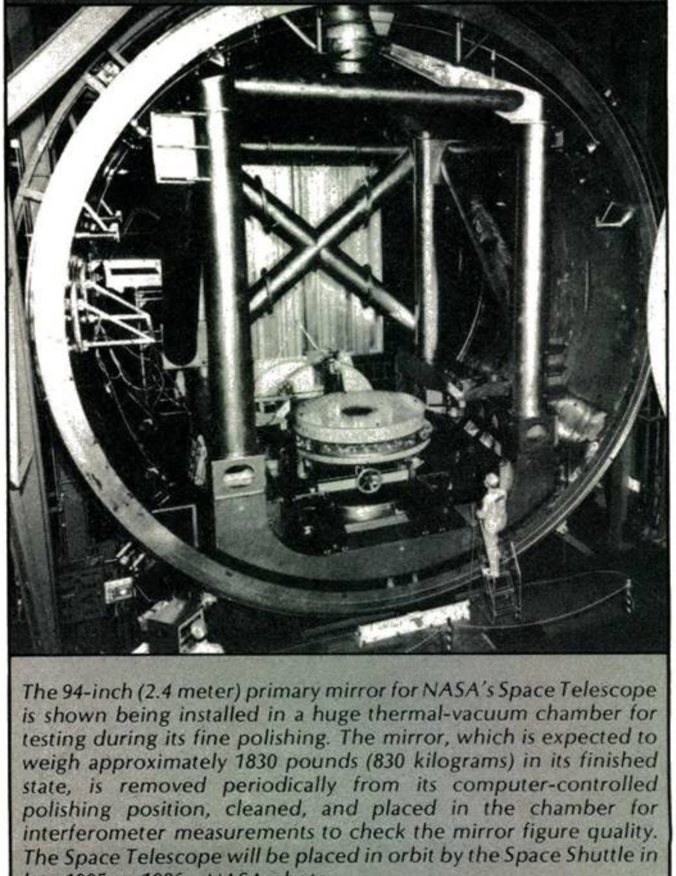
The Voyager flybys of Jupiter in 1979 confirmed the presence of water vapor and other gases in the jovian atmosphere that could support life. The two spacecraft also detected lightning, which scientists believe can provide the energy needed to create life forms. Because of recent scientific discoveries on Earth as well as in space, experts believe it is possible that some form of life could exist in Jupiter's atmosphere.

One man who shares this view is Dr. Ronald Bracewell, professor of astronomy at Stanford University. "While I believe Jupiter has a solid surface, the conditions in the atmosphere are more conducive to life. It is certainly possible that some form of life exists in the jovian atmosphere."

According to some scientists, it is even possible that life forms in Jupiter's atmosphere could possibly be larger then just microscopic size. Dr. Paul Deal, a biologist at NASA's Ames Research Laboratory, says, "One can visualize higher life forms, something like floating gas bags." And a recent study conducted at the Naval Biosciences Laboratory in Oakland, California, showed conclusive evidence that certain bacteria can not only live in a gaseous environment, but reproduce succeeding generations.

Dr. Robert Dimmick of the Naval Biosciences Laboratory

Space Telescope Mirror Tested



The 94-inch (2.4 meter) primary mirror for NASA's Space Telescope is shown being installed in a huge thermal-vacuum chamber for testing during its fine polishing. The mirror, which is expected to weigh approximately 1830 pounds (830 kilograms) in its finished state, is removed periodically from its computer-controlled polishing position, cleaned, and placed in the chamber for interferometer measurements to check the mirror figure quality. The Space Telescope will be placed in orbit by the Space Shuttle in late 1985 or 1986. NASA photo.

said, "If the bacteria can reproduce in the air, then the chances are probably better that they can reproduce in the jovian atmosphere."

Another scientist, Dr. Sanford Siegel of the University of Hawaii, agrees that Jupiter's atmosphere could contain life. He studied a living bacterium that is related to an organism which existed on Earth two billion years ago in an atmosphere similar to Jupiter's. This, he felt, demonstrated that Jupiter could have a very good chance of harboring some form of life.

The Latest on Pluto

The solar system's outermost planet Pluto was discovered in 1930, but next to nothing was known about it until the last few years. Even such fundamental facts as its diameter, mass, and density have long been subjects of disagreement and debate among astronomers.

The dam began to break with the discovery of Pluto's moon Charon in 1978. Observation of the moon's orbit allowed the first precise calculations of the total mass of the plutonian system, but the results seemed hard to believe. To the surprise of many astronomers, the mass of Pluto and Charon turned out to be far less than the most conservative previous estimates. This meant that, even assuming Pluto were small, its density would be less than water.

These difficulties led some astronomers to doubt the existence of Charon. Its closeness to Pluto makes it in fact very difficult to observe, and the dissidents pointed out that Charon had not been observed as a separate, distinct body.

Some support for Charon's existence came in April of 1979, when Pluto passed very close to a star. Although calculations indicated that Pluto would not actually occult the star, Charon was in an orbital position which would bring it in front of the star for extremely southern observers. And in fact, Alistair Walker of the South African Astronomical Observatory saw the star occulted for 50 seconds at just the right time.

Now two French astronomers have succeeded in photographing Charon as a separate object, and made a number of other measurements as well. D. Bonneau of the Centre d'Etudes et de Recherches Geodynamiques et Astronomiques at Caussols and R. Foy of the Observatoire de Paris at Meudon used the new 3.6 meter Canada-France-Hawaii telescope on Mauna Kea in Hawaii to observe the plutonian system. Employing the technique of speckle interferometry, they were able to isolate the image of Charon from that of Pluto.

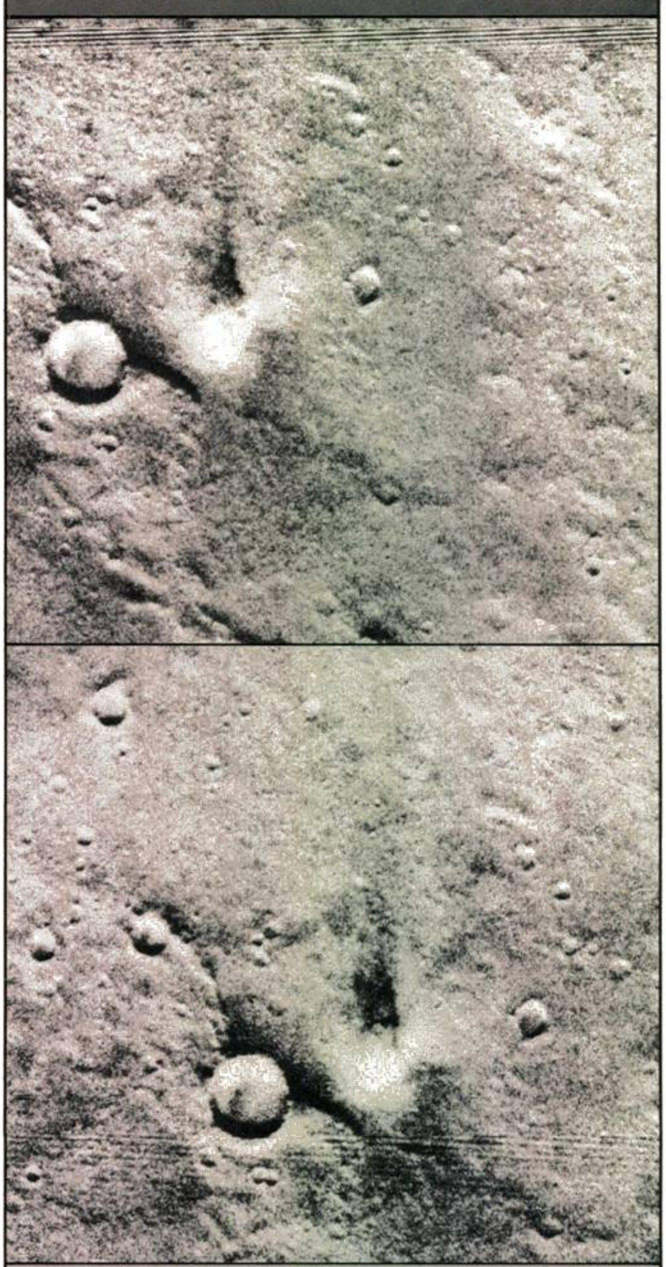
The technique involves averaging a large number of very short images to remove random "noise" and distortion caused by Earth's atmosphere. Charon turned out to be 1.6 magnitudes fainter than Pluto, which — assuming their surfaces to be equally reflective — implies its diameter is one-half that of Pluto. (A difference of 1.6 magnitudes corresponds to a difference in brightness of four times.) The astronomers found Pluto's diameter to be 4000 kilometers (2500 miles), and that of Charon to be 2000 km (1250 miles).

Charon's orbit is circular, at a distance of 19,000 km (11,800 miles). Using Bonneau and Foy's results, James Christy (who discovered Charon) and Bob Harrington of the U.S. Naval Observatory have derived a more accurate value for the total mass of the plutonian system of 1/400 that of the Earth. Assuming that Pluto and Charon are composed of the same materials and have the same density, Christy and Harrington find the average density of the two to be 0.4 grams per cubic centimeter — less than half that of water. Therefore Pluto, with a mass about a sixth that of our Moon, and Charon, 1/50 the Moon's mass, seem to be snowball-like bodies of frozen methane.

Other astronomers have recently reported the detection of a thin atmosphere of methane gas on Pluto. The observation was made in May of 1980 with the 61-inch University of Arizona telescope near Tucson, Arizona, and revealed spectral lines characteristic of gaseous methane.

It may be that Pluto has an atmosphere only when it is in the inner part of its orbit, which takes it closer to the Sun than Neptune. The

An Active Volcano on Mars?



Ever since the Mariner and Viking missions to Mars first revealed the red planet's surface in detail, Mars has been famous for its huge volcanos. But the largest volcanos are ancient, and quite certainly extinct. Other photos of Mars have revealed many small volcanos as well, whose ages cannot be determined with any accuracy, but which have been thought to be at least dormant if not extinct.

Now, however, the first indication of possible volcanic activity on Mars has been discovered on these photographs, taken by the Viking Orbiter 1 on August 1, 1978 — over two years ago.

A small and unusual cloud formation, about 400 to 500 meters (1200 to 1500 feet) across, casts a shadow on the surface. It is located at 16° south, 80° west in the Sinai Planum region, on the eastern slope of the great Tharsis bulge. Dr. Leonard Martin of Lowell Observatory, Flagstaff, Arizona, who has been studying martian clouds intensively for several years, first directed other scientists' attention to these photos.

The lower picture was taken just 4.48 seconds after the upper image, and the change in the cloud's shape — and especially that of the shadow — in so short a time prompted Dr. Martin to suggest that it might be a column of steam coming from a geyser or a very small volcanic vent. If his interpretation is correct, it is the first evidence for such contemporary activity on Mars. NASA/JPL photos.

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slightly greater heat Pluto receives from the Sun as it nears perihelion (in 1989) may evaporate some of the frozen methane on Pluto's surface, resulting in a thin and temporary atmosphere.

Galaxies in Collision

Australian astronomers have found evidence that the Milky Way collided with — and swallowed up — another galaxy about two billion years ago.

The astronomers, from the Australian National University in Canberra, base their theory on the discovery of several hundred million very high velocity young stars on the outer edge of the Galaxy. These stars have different orbits, speeds, and chemical compositions compared with the predominantly slow-moving stars of the Milky Way, and their existence has been a mystery until now.

According to the team, led by Dr. Alec Rodgers, professorial fellow at the university's Mount Stromlo Observatory, the only explanation for the existence of these stars is that they were formed when the Milky Way collided with and "cannibalized" a smaller galaxy. The spectacular collision led to the formation of about 700 million "maverick" fast-moving stars and the disappearance of the smaller galaxy which the astronomers believe could have been a companion to the Milky Way's two small satellite galaxies, the Magellanic Clouds.

Dr. Rodgers became interested in these maverick stars about ten years ago, but it is only recently, with the aid of new equipment built by university engineers, that the team has been able to use the observatory's 188 cm (74 inch) telescope to study the outer regions of the Milky Way.

The astronomers found that these maverick stars, which normally make up only about a tenth of one per cent of the total number of stars in the Galaxy, predominate in the outer regions. Dr. Rodgers said it became clear that the stars posed a problem to current theories of the evolution of the galaxies and a new hypothesis was needed to explain their existence. The maverick stars are not only fast-moving but are also rich in metals. Other stars in the Galaxy are either old, fast-moving, and poor in metals or young, slow-moving, and rich in metals.

He said that if they are right in the interpretation of their results, they have strongly improved the evidence for galactic cannibalism and added a new dimension to our understanding of the Milky Way and its relationship to the Magellanic Clouds.

He developed the galactic collision theory early in 1980 and since then he and his colleagues have become increasingly convinced by the theory. "It is a unifying hypothesis that affects many problems of interpreting stars in the Milky Way," he said.

NGC-3986/88 may be two galaxies colliding. Such a collision involving our own Galaxy may have taken place two billion years ago. © Kitt Peak National Observatory photo.

Astrophoto IV

Astrophoto IV, a seminar on astrophotography, will be held Saturday, February 28, 1981 at Cypress College, near Long Beach, California. Sponsored by the Orange County Astronomers and the Ventura County Astronomical Society, this information session is the fourth such event in a series started in 1975.

The last seminar, held in 1979, drew over 200 participants to hear talks on amateur and professional techniques and applications of astrophotography. Also, a book of proceedings was printed and distributed to participants and 200 other interested parties worldwide. This year, 500 books will be printed to satisfy the anticipated demand.

Papers and photographs for publication and exhibition are being solicited, with a January 15, 1981 deadline for inclusion in the proceedings. A commercial exhibits area will also be available.

More information and a participant's kit is available from:

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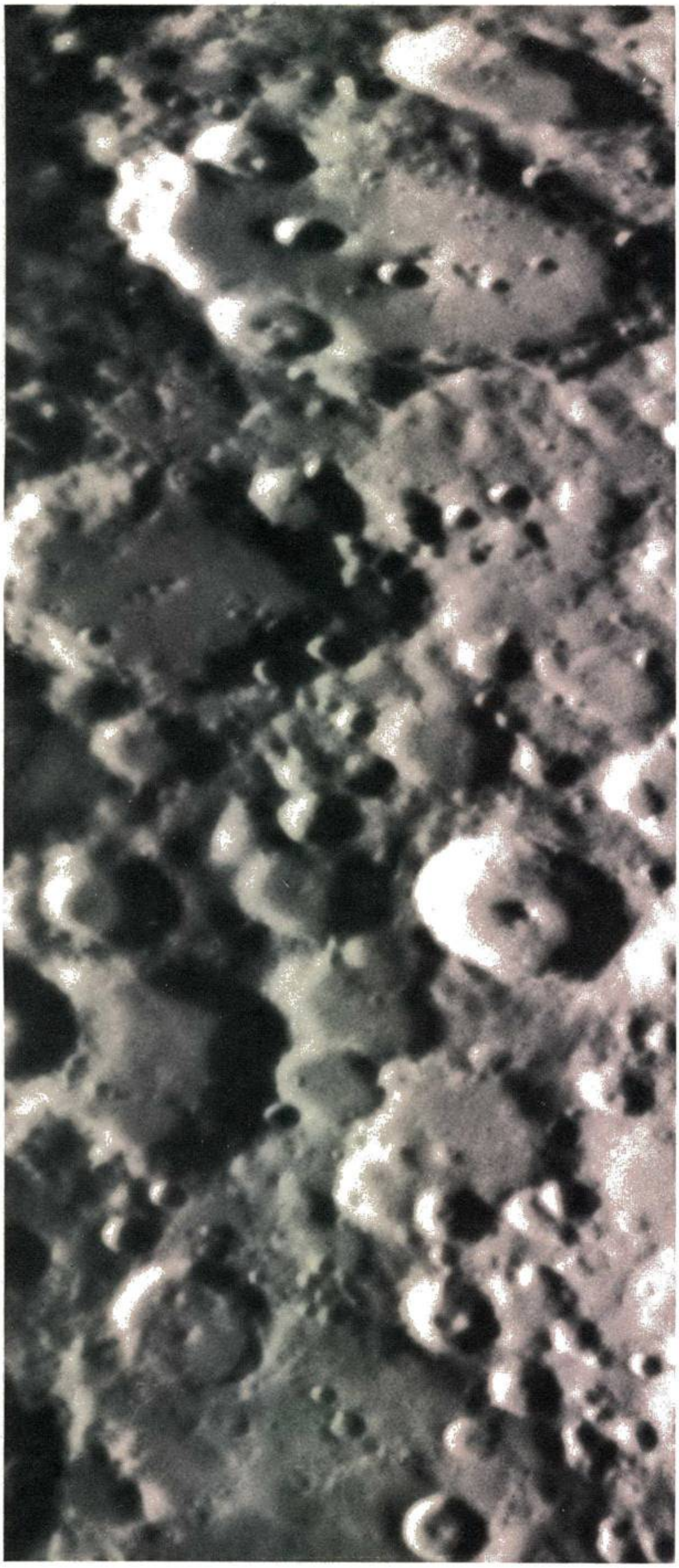

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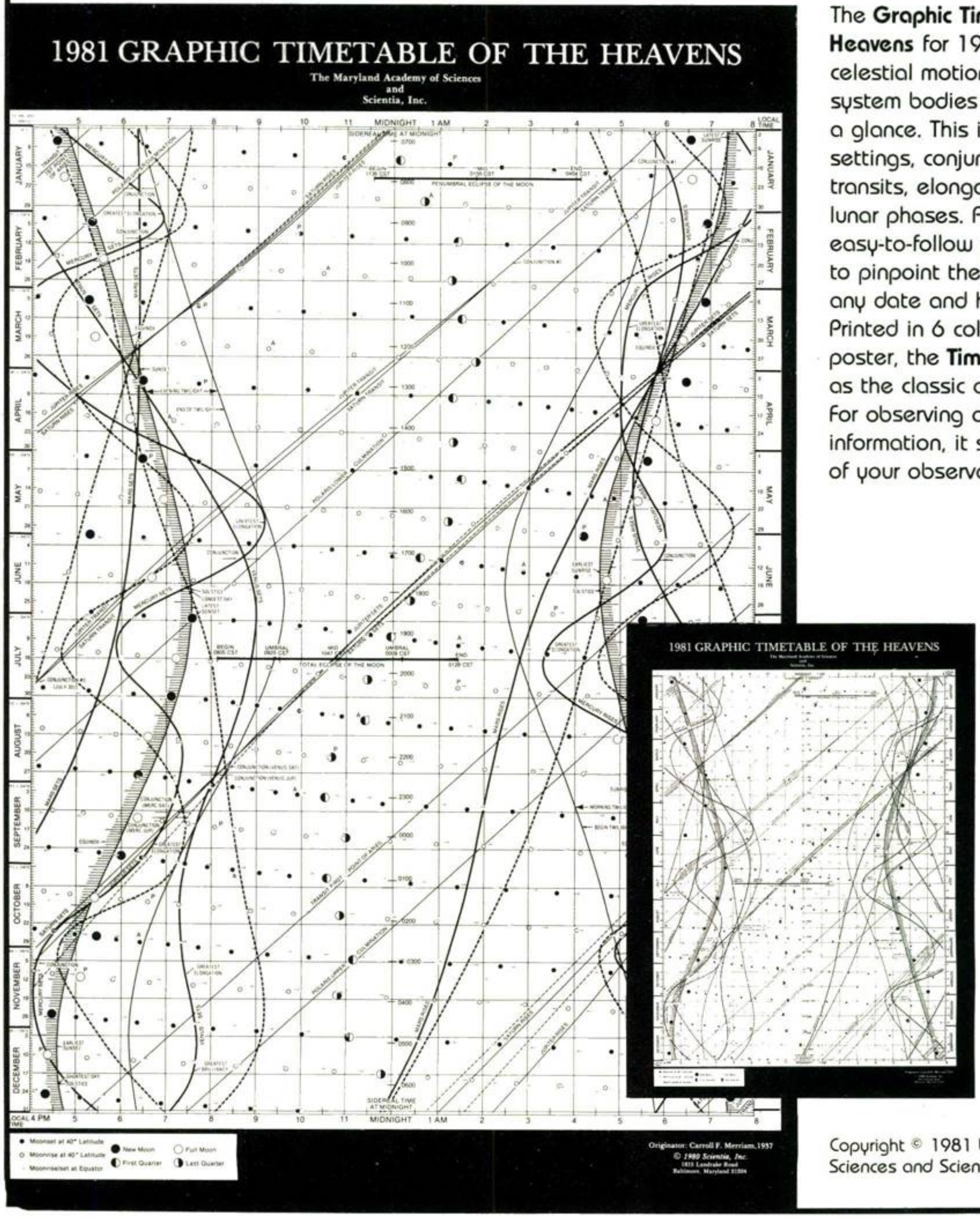

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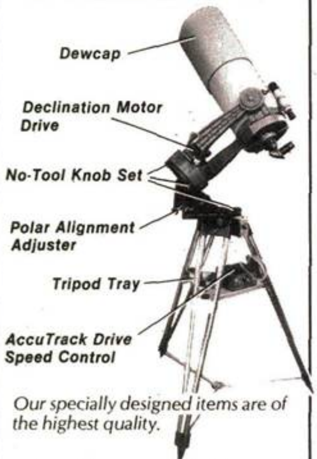

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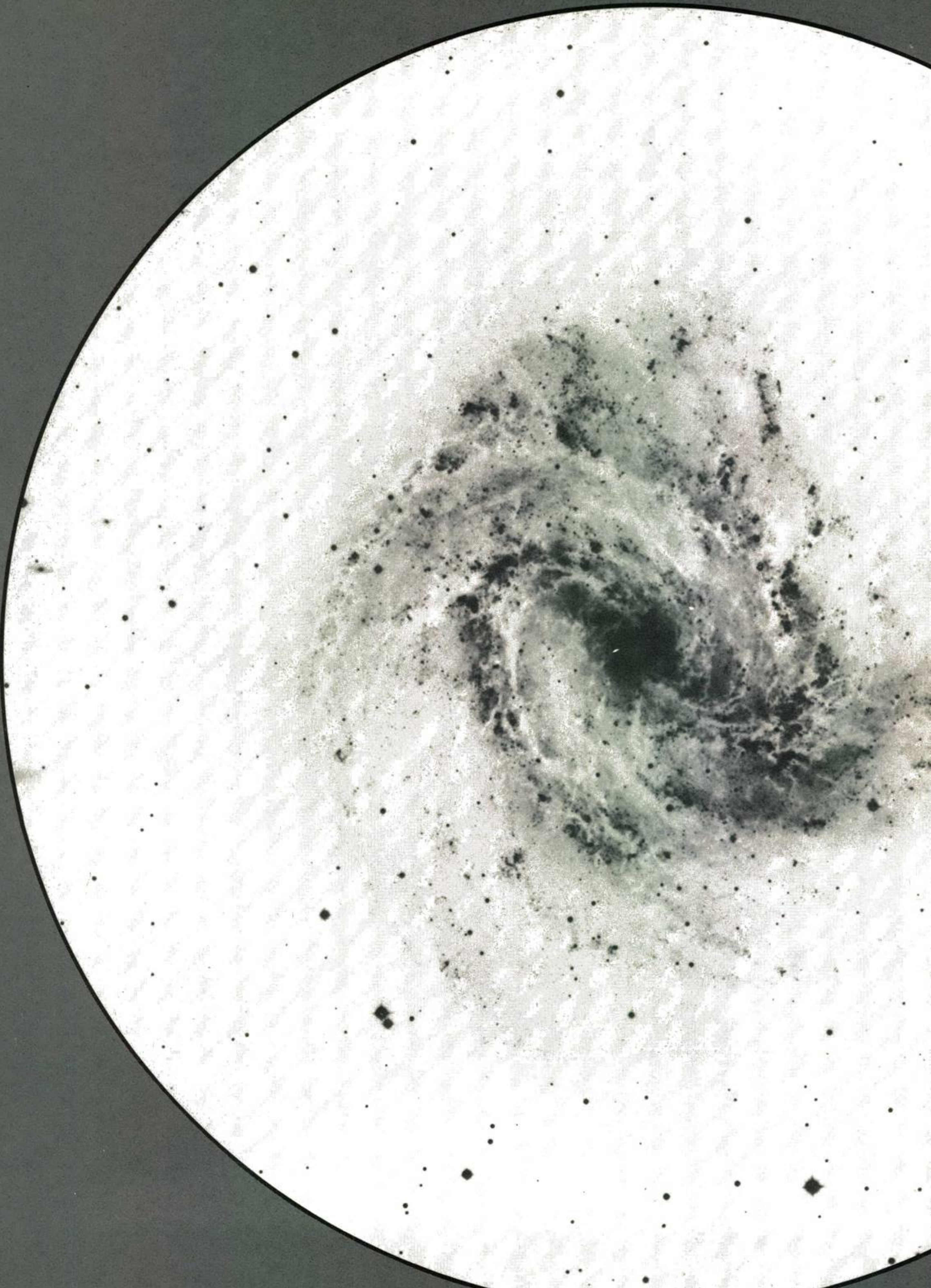

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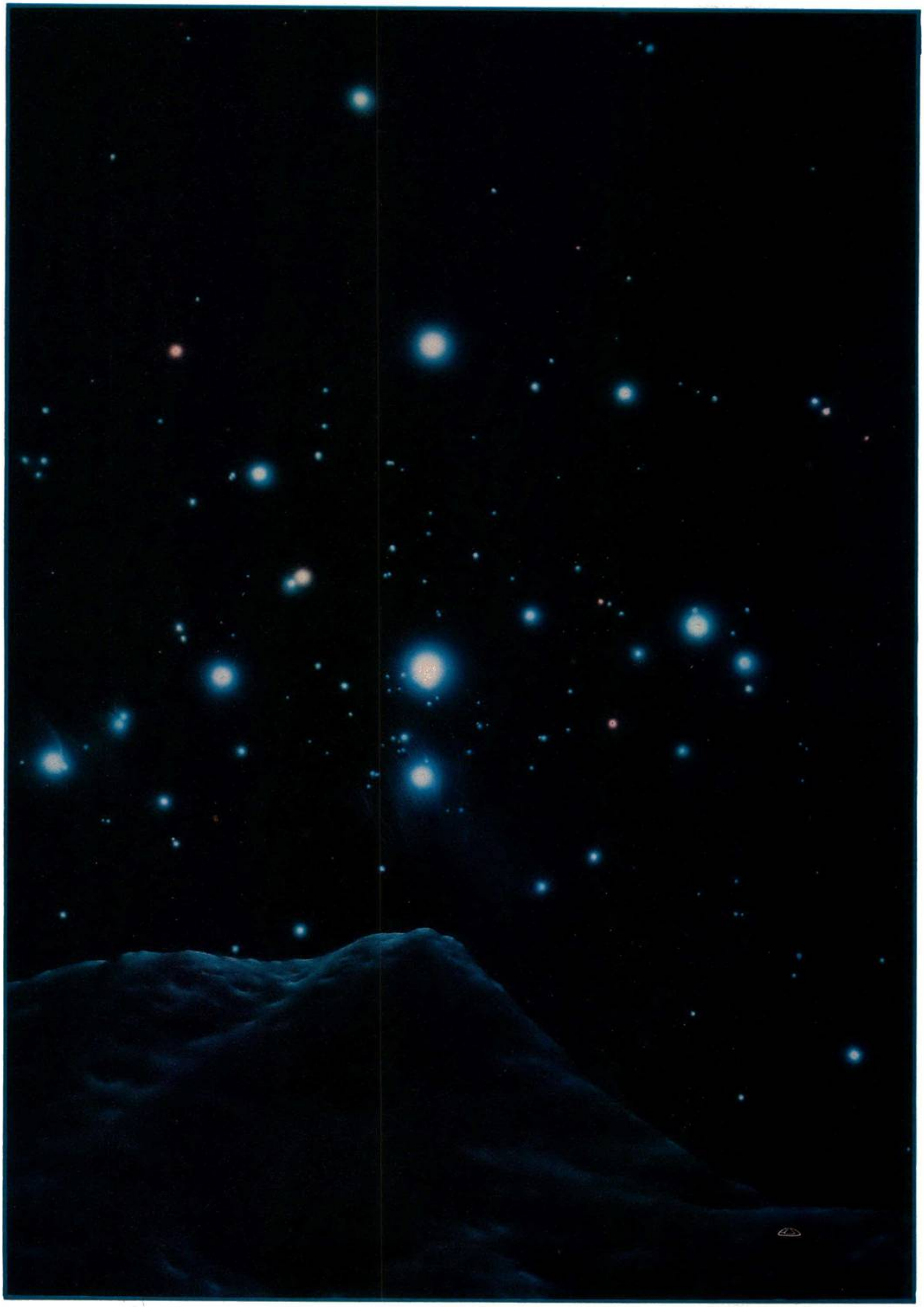
Is the Universe Spinning?

by
Paul S. Wesson

Astronomers can understand most astronomical observations on the basis of a handful of simple physical laws, even though the objects which we can observe range in size from asteroids (a few kilometers) to giant superclusters of galaxies (10^{21} kilometers or 100 million light-years). A **law** simply means a regularity in Nature which holds for a variety of objects and circumstances which are otherwise different.



As a typical case, consider the galaxies we observe in the universe: they have different masses and shapes, they lie at different distances from us and move with different speeds, and there are billions (at least!) of them, but they all closely obey a simple rule known as Hubble's Law. If we simply measure the recession velocities of the galaxies and compare them to the distance inferred from the brightness, or that of the variable stars in them, we find that the velocity is directly proportional to the distance. This appears to be a regularity in Nature — and one now well enough confirmed to be called Hubble's Law. This law states that the velocity of recession (v) of any galaxy with respect to our own galaxy (the Milky Way) is related to its distance (r) by the equation $v = Hr$, where H, known as Hubble's Constant, is the constant of proportionality.

Recently a new regularity in Nature has begun to emerge from cosmological research — a regularity which may eventually become established as a new astronomical law. After we see how it was formulated at first purely as a theoretical abstraction, we'll discuss how it compares with observation and conclude by making a prediction that might hopefully be tested in the future.

Physical Laws and Their Application

Research in theoretical astronomy often proceeds by labeling properties of Nature with symbols and then finding relations between the symbols with the aid of mathematics. In other words, we state natural laws in the form of mathematical equations. Some of these equations are complicated — such as the equations in Einstein's Theory of General Relativity — while others are simpler — such as Newton's Inverse Square Law of Gravity. In both cases, these laws express our knowledge of the force of gravity, although the first has a wider scope than the second. Both cases represent laws which were first formulated theoretically and later confirmed by observation as being correct descriptions of our world.

However, there is another kind of law, one which is logically different from the type to which Einstein's and Newton's theories belong. When we examine a broad range of objects, we sometimes find a law of this second sort. Nature seems, as we have seen, to "prefer" the simple dependency $v = Hr$ of Hubble's Law over other more complex rules which physical theory would also allow. Thus, we see that there are two distinct types of law: (a) the "abstract" laws (like Einstein's and Newton's) which allow a whole range of logically acceptable and mostly complex alternatives and (b) the "practical" laws (like Hubble's Law) in which Nature in some mysterious way "picks out" simple relations that describe something in our actual universe — the universe we live in. Hubble's Law, for example, is characteristic of our universe — but other laws would not have violated accepted physical theories.

How does Nature pick out the practical laws for the universe we live in from the ones allowed by human-invented abstract law theories? The answer is most easily found by turning it around to put the onus of explanation *not* on Nature but on ourselves: Why is it that our abstract laws of physics allow so many concrete possibilities when applied to cosmology? Why is it that we can construct so many hypothetical universes that obey Newton's and Einstein's laws of physics? The framing of the question in this form does not imply any criticism of Newton's theory or Einstein's theory. Einstein's theory in particular, while complicated, still cuts down the range of possible galaxy motions enormously from what can be imagined without it. Einstein's equations are helpful: without his theory as a guide it would have been much more difficult than it was to take the next step. Still, among the many hypothetical universes allowed by Einstein, we must search for criteria that can cut down the range of alternatives even more — down to the simple choices realized in Nature.

Individual stars are often associated together into stellar clusters such as the Pleiades, seen here from a planet near Pleione. Matter in the universe is organized into hierarchical systems of ever-increasing size, most of which are rotating and so possess angular momentum. Artwork by Adolf Schaller.

Scale-Free Laws

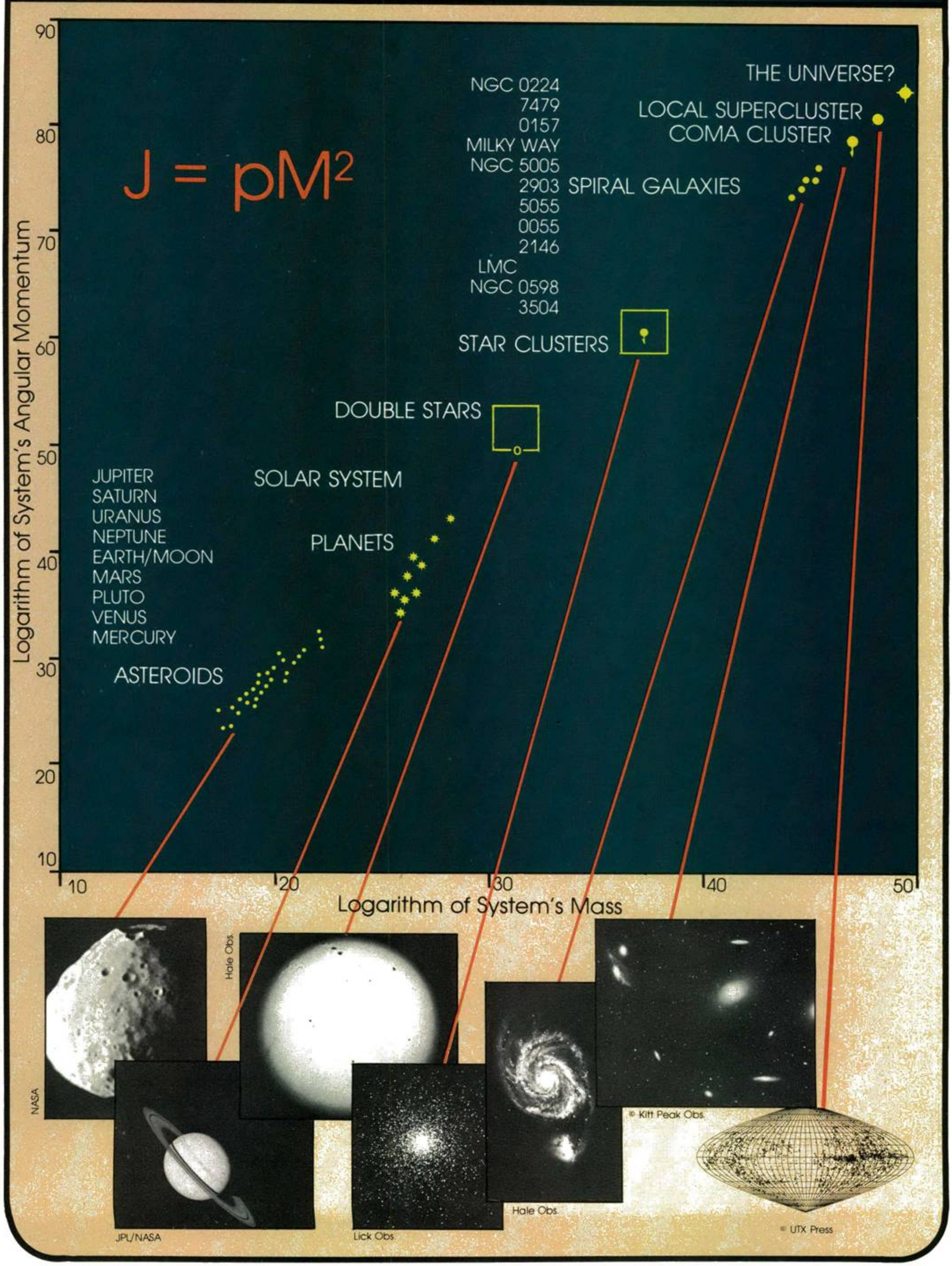
To explore why our laws of cosmology are so general, consider as an example the distribution of galaxies as described by Einstein's Theory of General Relativity. The motions of galaxies, like the motions of most astronomical objects, are mainly a result of the force of gravity.

Most galaxies in the universe are clumped together into clusters of various sorts. A typical "rich" cluster of galaxies contains between 50 and 1000 galaxies within a roughly spherical volume of size around 10 million light-years across. (A light-year, the distance traveled by light in one year, is about 10^{13} kilometers.) Within this volume the galaxies are more tightly packed towards the center — in other words, there is a density law according to which the density of galaxies in a cluster increases as the distance from the cluster center decreases. A supercluster has a similar law governing the distribution of its member galaxies, but may contain several individual clusters and smaller groups of galaxies. A supercluster may have a total population of as many as 10,000 galaxies within a volume of size 100 million light-years across. A study of the distribution of galaxies in clusters and superclusters shows that their typical properties are a result of the following rather interesting fact: Nature measures a mass M by a combination with two fundamental constants of physics, G (Newton's gravitational constant) and c (the velocity of light), and the volume of space the mass occupies. This combination of very different parameters represents an important clue as to why the naturally-occurring laws of galaxy distribution are only a very small subset of the alternatives not ruled out by the theory.

Compare this with what humans do when we measure a mass: We invent a standard unit of mass M_0 (a kilogram, for example) and say "This thing has a mass of M/M_0 kilograms." But this comparative procedure is fundamentally different from what Nature does, because we have invented an artificial unit (M_0). By contrast, Nature uses no fixed units, using instead only the natural standard given by the system itself. In other words, M_0 is not a vital constant of Nature (being human-invented), whereas G and c are truly fundamental constants.

Realizing this, it's not difficult to see that the distribution of galaxies in the universe we live in is

Rotation in the Universe



described by laws which are free of artificial units and scales. (Technically, such laws are termed *scale-free* or *self-similar.*) By banning all scales but those incorporating the fundamental constants G and c, it's possible to find a scale-free subset of all the possible solutions of Einstein's equations. This subset includes rules of galaxy distribution which, as it turns out, describe the distribution actually observed in the universe. In particular, expressions for masses, densities, and recessional velocities follow from such a scale-free formulation, and the recessional velocity rule derived from Einstein's equations is (as we might expect) the Hubble Law — which describes the expansion of the observed universe.

Mass and Angular Momentum

Encouraged by the success of the scale-free approach in deriving the observed rules of galaxy distribution in clusters and superclusters, let us now explore some other astronomical systems and see if we can find an even more general rule. No data are presently available for even larger systems, that is, it is not yet established if there exist clumps of larger size than superclusters, or if the superclusters are instead simply distributed uniformly throughout the universe. But when we consider smaller systems, there are considerable data: we know a lot about the properties of galaxies themselves, the star clusters contained in galaxies, individual stars (including the Sun), the planets in orbit around the Sun, and the smaller rocky bodies (asteroids) that move in interplanetary space. In other words, we have data on fully seven major classes of objects covering an enormous span of size:

(1) asteroids (1-100 km)
(2) planets (10^3-10^5 km)
(3) stars (10^6-10^7 km)
(4) star clusters (on the order of 10^{14} km or 10 light-years)
(5) galaxies (10^{18} km or 10^5 light-years)
(6) clusters of galaxies (10^{20} km or 10^7 light-years)
(7) superclusters of galaxies (10^{21} km or 10^8 light-years).

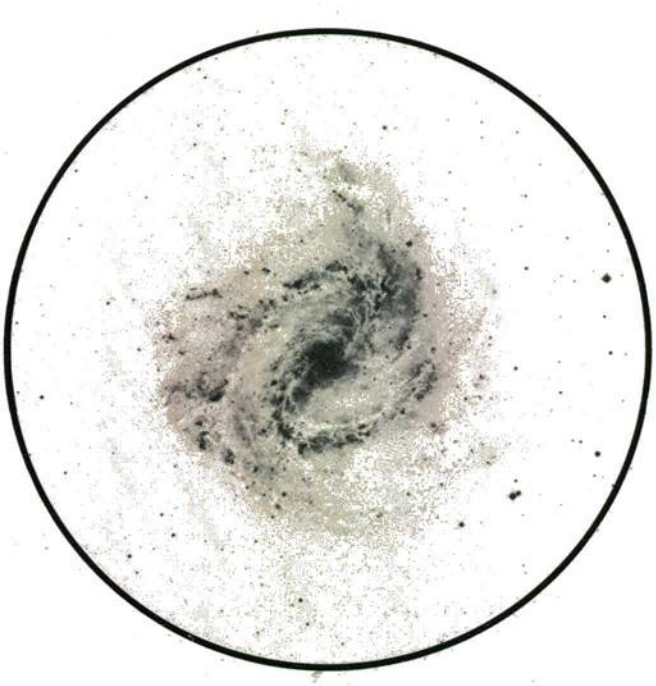
These classes of objects are, seemingly, about as different as they can be. At first sight, it might appear silly to suppose that there could be any common rule tying them all together. However, the scale-free approach worked well for systems of large size like classes (6) and (7), so there exists some justification for considering a possible scale-free rule that might also apply to objects of smaller sizes.

One thing that most of these objects have in common is that they are rotating. (Some astronomical systems, like superclusters, are apparently expanding and rotating at the same time — in such cases, Hubble's Law gives the radial or outward part of the velocity while the transverse or rotational part of the velocity is given by the scale-free rule.) Applying the scale-free criterion, it is not difficult to obtain simple rules for the densities and speeds of rotation of the systems concerned. If these two rules are combined, they yield a rule which actually has a wider applicability than the parts from which it was derived.

This new rule is scale-free, of course. It relates the rotation to the mass. Rotation is specified in terms of the quantity known as angular momentum, denoted by the symbol J. This quantity is of basic importance in all physical problems involving rotation (it is defined in terms of the mass times the rotational velocity times the distance from the center of rotation, but the angular momentum is actually more important than its component quantities in many situations in physics). With the mass denoted by the symbol M, the rule can be written in the form:

$$J = pM^2.$$

When rotating astronomical objects are plotted on a graph with mass against angular momentum, a clear correlation appears. The data fall along a straight line with a slope of 2, as predicted by the rule $J = pM^2$. Both axes are scaled logarithmically in order to fit the data on a graph of reasonable size. If it is valid to extend the rule to the entire universe, the prediction can be made that the universe as a whole should be rotating.



Here, p is a constant (it is a multiple of G/c, as expected from the preceding discussion). This rule, as it stands, can be singled out from the wide range of all possible angular momentum rules by using *only* the theoretical criterion of being scale-free (technically, of being self-similar). The question immediately arises of whether this rule is in fact obeyed by the bodies of the observed universe.

The diagram on page 70 presents a comparison of theory and observation. With axes scaled logarithmically, the law predicts that the J and M values of cosmic objects should fall on a straight line, and that the slope of this straight line should be 2. The agreement between theory and observation appears to be good. Employing numerical data for all the objects and systems considered enables us to obtain a rough value of the constant p as 10^{-15} cm^2/gm sec.

It is always nice when theoretical considerations lead to something which agrees with observation. (It gives us the feeling that we understand what we're doing and that we're on the right track.) However, experience shows that this feeling sometimes turns out to be misplaced (i.e., we could be wrong), and our belief in our understanding may be illusory. The $J = pM^2$ relation has to be confirmed by collecting more data before it can be considered as anything more than a *rule*. It will be of great interest to see if further astronomical data on rotations and masses confirm the rule.

Let's finish off with a daring prediction: If the $J = pM^2$ rule *does* hold good, then the line in the diagram can be continued outwards to even larger and more massive systems — and therefore the startling prediction can be made that the universe, as a *whole*, should be rotating!

Paul S. Wesson received his Bachelor's and Doctor's degrees from London and Cambridge Universities respectively. He is currently at the Institute for Theoretical Astrophysics of Oslo University in Oslo, Norway, and has published over fifty papers and a book, **Cosmology and Geophysics**. *One of his main fields of research is cosmology. His last article for ASTRONOMY was "The Cosmological Principle" (October 1979). His paper, "Self-Similarity and the Angular Momenta of Astronomical Systems: A Basic Rule in Astronomy," on which the present article is based, appeared in the journal* **Astronomy and Astrophysics**, *vol. 80 (1979).*

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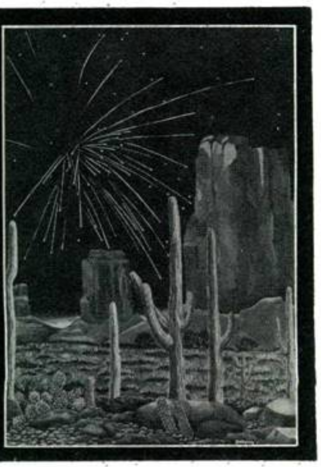

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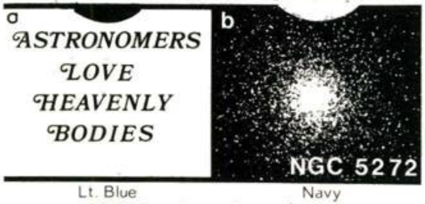

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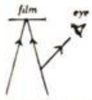

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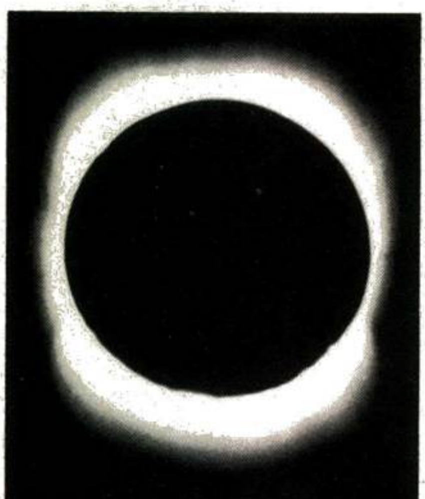

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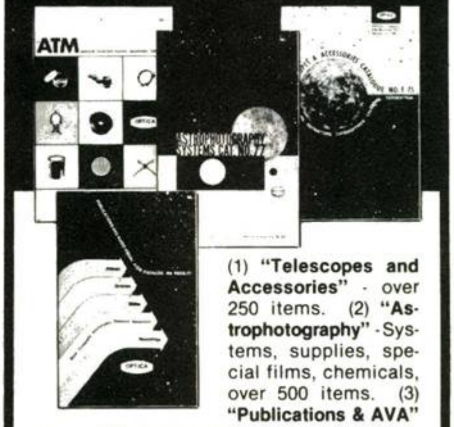

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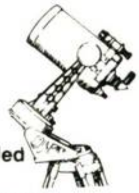

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ANNOUNCEMENT — Call for Papers — Papers and photos for exhibition are hereby called for. Astrophoto IV seminar will be held February 28, 1981 at Cypress College, Cypress CA. Proceedings book to be published. For registration/author info contact Orange County Astronomers, 2215 Martha Ave., Orange, CA 92667. Phone (714) 639-8446.

ANNOUNCEMENT — The Northwest Astronomy Amateur Radio Net has been operating for the past year. The net meets on Sundays at 10 p.m. PST (5 hrs. GMT summer, 6 hrs. GMT winter) on 3.930 MHZ in 80 meter amateur radio band. Wednesdays at 8 p.m. PST (3 hrs. GMT summer, 4 hrs. GMT winter) on 14.30 MHZ in the 20 meter amateur radio band. All radio amateurs are invited to participate.

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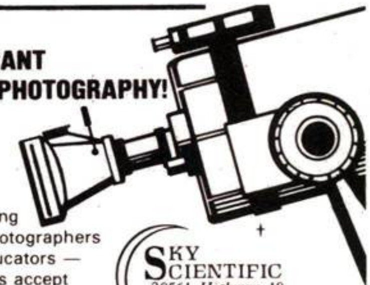

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close-up on orion

through the eyepiece

Mercury

Mercury sweeps out from the Sun to reach greatest eastern elongation on the 2nd of February and will be visible low in the western sky after sunset during the last 10 days or so of January. Look on page 84 for a diagram showing its motions each day, 45 minutes after sunset.

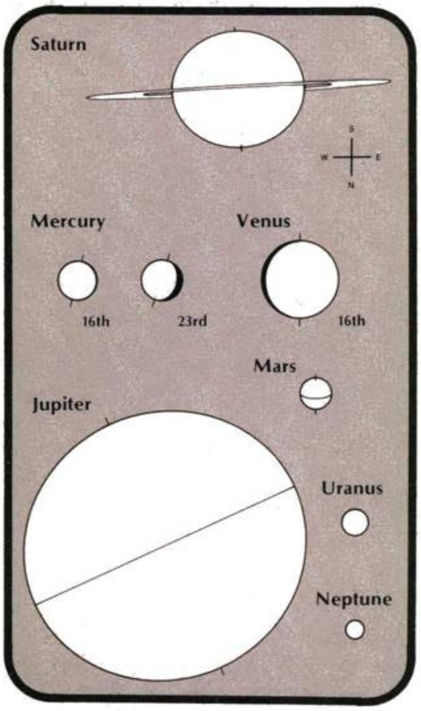
Additionally, on the evening of the 23rd, Mercury will be less than half a degree south of Mars. Both objects will be very low (about 4½° high, 45 minutes after sunset) and neither will be outstandingly bright: Mercury will be at -0.9 magnitude, Mars +1.4. In a telescope, Mars' disk will appear 4" of arc in diameter, Mercury's 5.5"; Mars will resemble a round dot, Mercury not quite so round. Despite their tiny apparent sizes and relatively dim magnitudes, don't pass up this event!

Venus

By the end of January, Venus has effectively disappeared from the morning sky. Starting at less than 10° altitude on the 1st, it'll sink rapidly lower day by day. Superior conjunction with the Sun doesn't come until April 7th, though, and it won't be until mid-May that you'll spot it reappearing in the evening sky.

In the meantime, watch for two conjunctions a day apart: with the Moon on January 4th and with Neptune on the 5th. Before sunrise on the 4th, the Moon (waning crescent 27.5 days old) will lie about 3° to the left of Venus. At the same time, Neptune (dim at magnitude +6.0 — use binoculars or a telescope) is between them and about a degree lower. By the same time the next day, Neptune has risen a bit and Venus has sunk to bring them within a degree of each other.

Around 10:00 UT on the 11th, Venus will pass in front of the Trifid Nebula, M-20, in Sagittarius. This happens before "Venus-rise" for even the most eastern parts of the continent, but try to see what you can a bit later that morning when the planet and nebula both rise.



Ron Gattie's fine photo of the Sun (the "Best Astro-Photo" for January) was taken with a filter that transmits H-α light. He exposed 64 ASA film for ⅛ second at f/11 with his 8" Schmidt-Cassegrain telescope. (A shorter exposure would have recorded filaments across the Sun's face, but lost the wispy flares we see here.)

Earth

At 2h UT on January 2nd, Earth will be 0.9833187 astronomical units (146.5 million kilometers) from the Sun. This is perihelion, or our planet's closest approach to the Sun. Aphelion (farthest distance) comes almost 183 days later, at 23h UT on July 3rd.

Moon

At 10:34 UT on January 2nd, the Moon will lie almost 5° north of Uranus in the morning sky; such a "conjunction" is an event for binoculars — though you'll have to use a telescope if you want to make out Uranus' 3.5" disk.

On the morning of the 4th, look for it near Venus and Neptune, as we mentioned before (in the Venus section).

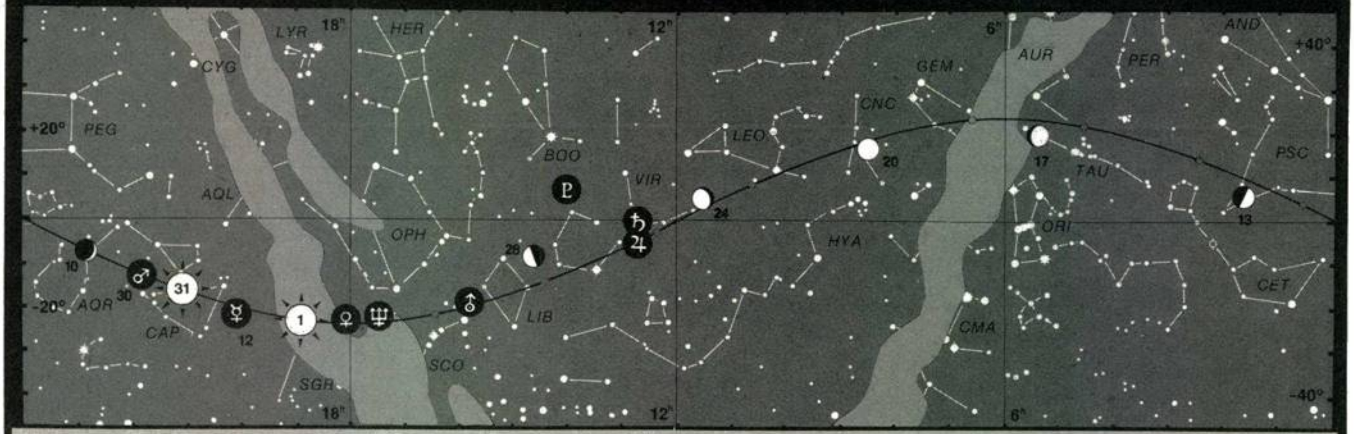
About 38 hours after New, the Moon will pass Mars (lying 1° 34' to the south) at 21:12 UT on the 7th. That evening, the Moon will show as a very slender crescent a little higher than the dim (+1.5 magnitude) planet. Both will be quite low in the southwestern sky.

On the 16th, when its phase has become gibbous, the Moon passes in front of Aldebaran, although no occultation happens for North America. By the time the Moon rises for us, it'll have moved on to the east of the star.

On the 20th, at Full Moon, there'll be a penumbral lunar eclipse visible in its entirety from all of North America. The event begins with the Moon entering the Earth's penumbral shadow at 5:36 UT. Mid-eclipse happens at 7:50 UT and the Moon leaves the penumbra at 10:04 UT. Since the penumbra will swallow the Moon's disk wholly, you'll see a pronounced darkening, especially across its northern regions. (The Moon is transiting the southern part of the penumbra, with the umbra — the totally eclipsed region — lying just to the north of it.) Around mid-eclipse look for some yellowy coloring.

A waning gibbous Moon, 18.7 days old, will crawl past Saturn and Jupiter in the early hours of the 25th. At the times of conjunction (17:21 UT for Saturn, 17:45 for Jupiter), all three will be high in the western sky. But you'll get a more striking view several hours earlier (around 1 a.m. local time) as the

planetary data january 1981


LYR
18h
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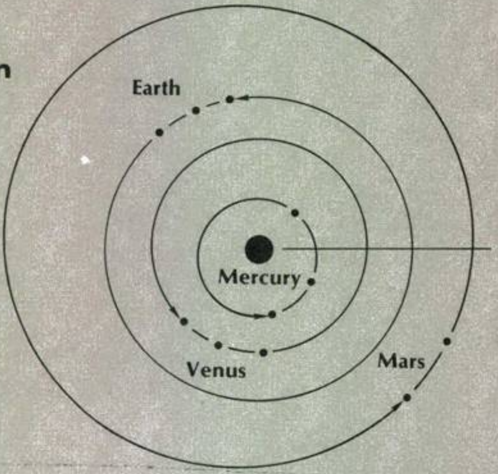
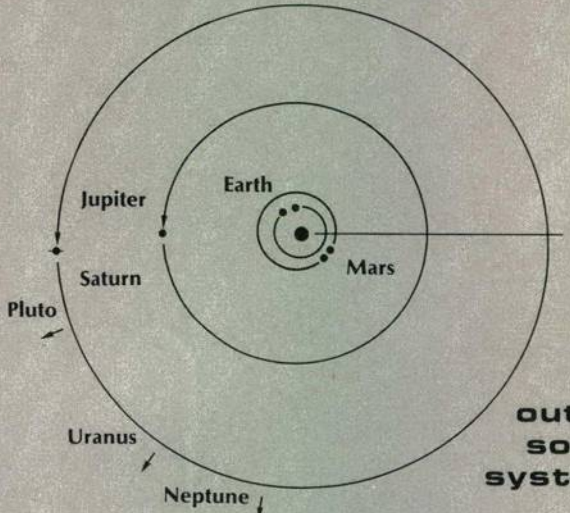
-40°

inner solar system


Earth
Mercury
Venus
Mars


Jupiter
Earth
Saturn
Mars
Pluto
Uranus
Neptune

outer solar system

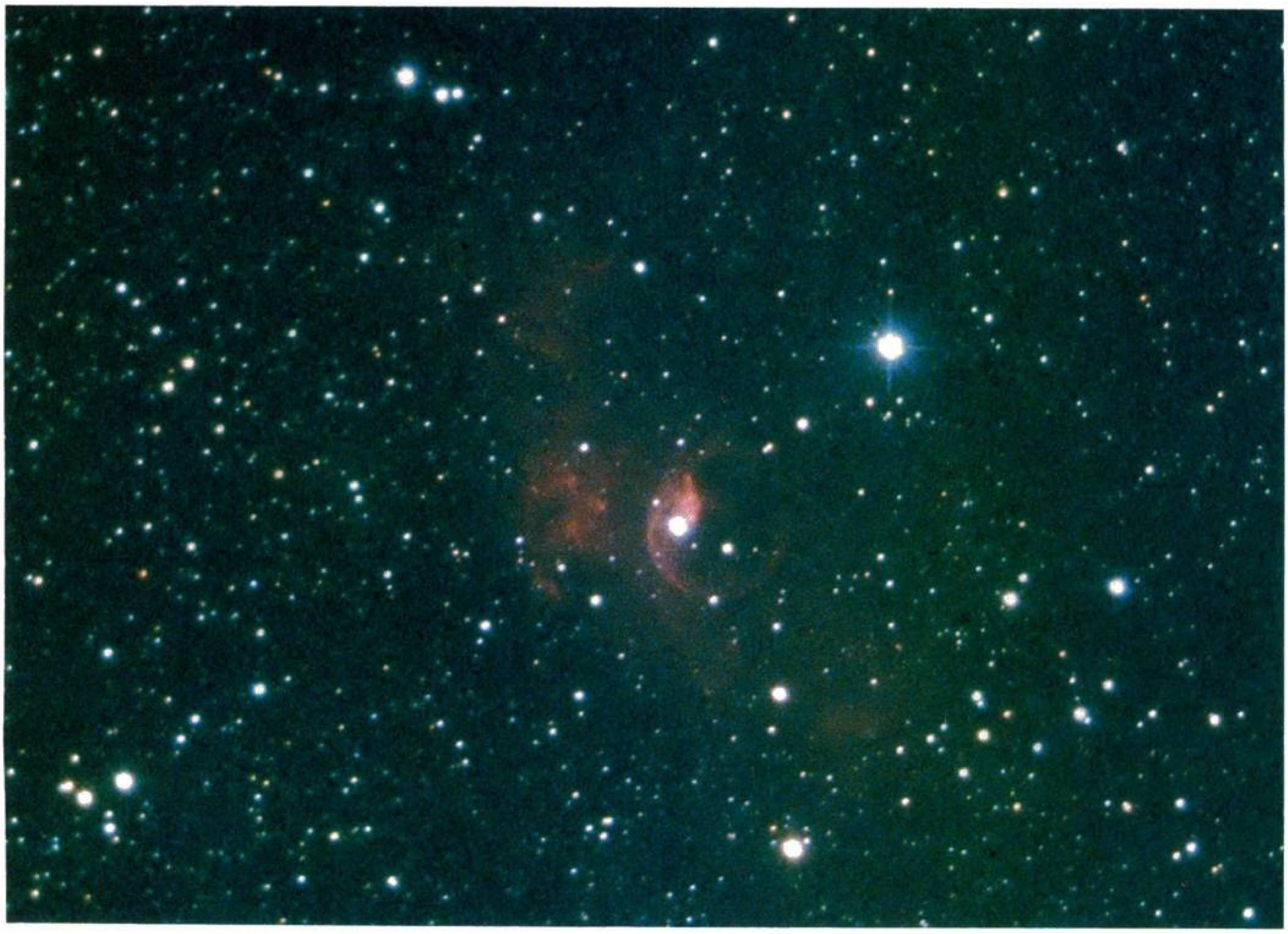
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (1981.1)	Dec
Sun		10	--	32.6′	--	0.98	--	--	289°40.3′	19 25.1	-21°59.9′
		20	--	32.6′	--	0.98	--	--	299°51.3′	20 08.1	-20°11.0′
Mercury	☿	10	-0.9	4.8″	98%	1.39	0.42	309°28.7′	295°09.2′	19 51.8	-23°06.3′
		20	-0.9	5.3″	91%	1.26	0.37	347°46.3′	311°55.8′	21 01.4	-18°48.5′
		30	-0.7	6.4″	66%	1.04	0.32	39°00.1′	327°17.8′	22 00.6	-12°32.3′
Venus	♀	10	-3.4	10.9″	93%	1.55	0.72	238°55.4′	267°58.5′	17 53.0	-22°56.9′
		30	-3.3	10.5″	96%	1.61	0.73	254°49.6′	293°00.0′	19 41.4	-21°46.6′
Mars	♂	15	+1.4	4.1″	99%	2.29	1.38	323°56.3′	311°26.1′	20 58.6	-18°18.2′
Jupiter	♃	15	-1.7	38.5″	100%	5.11	5.44	180°09.9′	189°47.6′	12 39.8	-2°47.7′
Saturn	♄	15	+1.0	18.0″	100%	9.23	9.53	184°03.1′	189°19.9′	12 39.7	-1°38.7′
Uranus	⛢	15	5.9	3.6″	--	19.33	18.79	236°36.4′	238°29.4′	15 47.5	-19°43.7′
Neptune	♆	15	7.8	2.4″	--	31.11	30.28	262°36.1′	263°03.9′	17 32.2	-21°58.9′
Pluto	♇	15	14.0	--	--	30.06	30.08	202°21.9′	203°45.6′	13 55.1	6°32.2′

moon data

New Moon	January 6 at 07:24
First Quarter	January 13 at 10:10
Full Moon	January 20 at 07:39
Last Quarter	January 28 at 04:19
New Moon	February 4 at 22:14
First Quarter	February 11 at 17:49
Perigee: January 15 at 4h	369,683 km
Apogee: January 27 at 20h	404,310 km

universal time

Astronomers the world over use an unambiguous system of time reckoning based on a 24 hour clock, called Universal Time (UT). Times in Through the Eyepiece are UT unless noted otherwise. To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska and Hawaii, 10. For example, if an event is to happen at 03:00 hours UT on Jan. 2, then the time in EST would be 10 p.m. Jan. 1. Likewise, 03:00 UT on March 5 becomes, in PST, 7 p.m. on March 4.



Often called the Bubble Nebula, NGC-7635 is a large, distant diffuse nebula in Cassiopeia. Its general spherical shape is clearly evident as are the hot stars embedded within which light it up. Jack Newton used 400 ASA film in a cold camera at the prime focus of his 16" f/5 telescope; the exposure was 17 minutes.

trio rises in the east: then the Moon will lie 5° above Saturn and Jupiter with all three seen against the everyday horizon of trees and houses.

Four days later, at 21:16 UT on the 29th, the Moon makes its second pass at Uranus, this conjunction (like the previous) having a rather wide separation of 5°. Uranus will lie to the lower right of the Moon.

Late on the last day of January (at 23:05 UT), the Moon passes north of Neptune once more, missing it by 2° 34'. The best view will be before dawn on the 31st, when the Moon will be about 6° to the upper left of the planet.

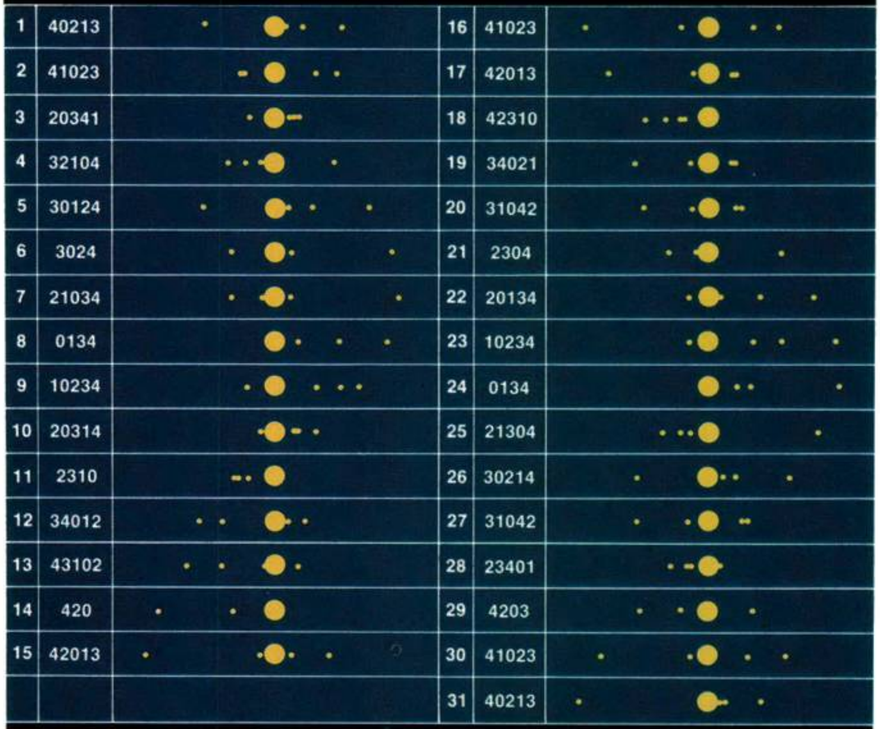
Mars

The single event of note involving Mars this month is its close conjunction with Mercury on the 23rd, described above in that planet's section.

Asteroids

1 Ceres (magnitude: +6.5) is at opposition on the 10th and at 7h 30m

satellites of jupiter 8:00 ut



1	40213	16	41023
2	41023	17	42013
3	20341	18	42310
4	32104	19	34021
5	30124	20	31042
6	3024	21	2304
7	21034	22	20134
8	0134	23	10234
9	10234	24	0134
10	20314	25	21304
11	2310	26	30214
12	34012	27	31042
13	43102	28	23401
14	420	29	4203
15	42013	30	41023
		31	40213

Jupiter = 0, Io = 1, Europa = 2, Ganymede = 3, Callisto = 4
(South is at top, matching the view in a telescope)

M-11 is either a rich open cluster or a sparse globular — take your pick! About 6,000 light-years away in the direction of Scutum, the cluster has some 600 members all told. Clive Gibbons (of Burlington, Ontario) took the photo with 400 ASA film, an 8″ Schmidt-Cassegrain telescope, and a 30 minute exposure at f/7.5

54s, 30° 44′ 28″ on the 15th, which places it near the Gemini-Cancer border.

On the 15th, 2 Pallas (+8.7) lies at 2h 07m 47s, -21° 34′ 07″ in Cetus-Eridanus, an area that sets around local midnight.

3 Juno (+11.0) can be found in Virgo, at 14h 13m 18s, -7° 30′ 15″.

4 Vesta (+7.1)is at 10h 57m 21s, 14°00′ 10″ on the 15th, which locates it in the middle of Leo.

(All positions are apparent.)

Jupiter & Saturn

Both these planets lie near the beautiful 3rd magnitude double star, Gamma Virginis — Jupiter in fact being only a degree and a half south and a little west of the star. Yet close as they come now, neither will pass the star in right ascension until this fall: Jupiter in late August, Saturn in mid-September. Between now and then, both planets appear to make a large retrograde loop to the west as Earth (thanks to our speedier orbit around the Sun) overtakes them.

But Jupiter *will* overtake Saturn this month: at 8:02 UT on the 14th, it'll pass 1° 9′ south of Saturn. This is the first in the series of three that mark the "Grand Conjunction" for the pair. (See Eye on the Sky, page 30.) The next conjunction will be on February 19th, when Jupiter passes 1° 9′ south of Saturn in its westbound retrograde loop. Their last meeting in the conjunction series will be on July 30th with a separation of 1° 12′.

During January, Saturn's rings are tilted to our line of sight about 7.3° and we are looking onto the northern side of them. The Sun also lies on this side of the rings, but at an angle of only 5°. By comparison, we are looking about 2.5° south of the jovian equator.

Uranus

Finding Uranus will be easy this year because several bright stars lie in its vicinity to guide you. You can locate it either by means of the two conjunctions with the Moon (described in that section) or by centering the 2.9 magnitude star Beta (β) Scorpii — a pretty double — in a low-power eyepiece. Then scan due west about 4° (4¾° in early January, 3½° in late January), looking for a 3.5″ of arc disk at magnitude 6.0.

Neptune

Being dimmer, smaller, and closer to the Sun in the sky than Uranus, Neptune's a mite harder to find, but even so it'll be pretty simple. Its conjunction with Venus on the 5th (see Venus section) offers an easy way to locate it early in the month, and there's a somewhat distant conjunction (2 ½°) with the Moon on the 31st (see that section).

In between, look for it by centering on the star 51 Ophiuchi (magnitude 4.9) and scanning due north 2°. On the Star Dome map (dig out last June's), 51 Oph is the lefthand star of the two little ones immediately to the upper left of Theta (θ) Oph. Neptune has a disk 2.4″ of arc across and a magnitude of 7.8.

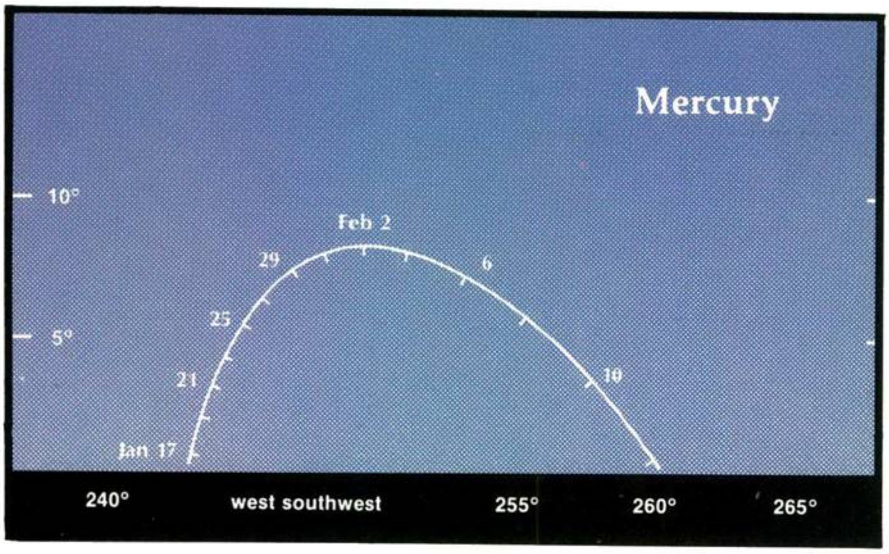
Meteors

January 3rd at 16h UT marks the time of maximum activity for the annual Quadrantid shower. Named after a now obsolete constellation (Quadrans Muralis — since absorbed into Bootes, Hercules, and Draco), the shower usually produces a great many — 30 to 40 per hour — faint bluish meteors. Since the average Quadrantid doesn't flash very brightly, the phase of the Moon on the peak night is critical and the prospects this year aren't too bad. Last Quarter was on December 29th; New Moon comes on January 6th. Keep your fingers crossed and hope for clear northeastern skies in the early morning hours of the 3rd!

elongations of mercury & venus — 1981

	Date	Altitude	Azimuth	Type of Elongation & Extent
Mercury	Feb. 2	8°	249°	East (evening sky), 18°
	Mar. 16	3°	110°	West (morning sky), 28°
	May 27	11°	294°	East (evening sky), 23°
	Jul. 14	7°	68°	West (morning sky), 21°
	Sep. 23	7°	246°	East (evening sky), 26°
	Nov. 3	10°	107°	West (morning sky), 19°
Venus	Nov. 11	15°	214°	East (evening sky), 47°

The planets' altitudes and azimuths are given for 45 minutes after sunset (east elongations) or 45 minutes before sunrise (west elongations) as seen by an observer at 40° north latitude — in other latitudes, the figures will vary a little. North = azimuth 0° (or 360°), east = 90°, south = 180°, and west = 270°.



minima of algol

(times of middle of primary eclipse)

Date	Time (UT)
Jan. 1	21:53
13	9:10
16	5:59
19	2:48
21	23:38

close-up on orion

"To know Orion is to know astronomy!" So wrote the classic observer Barns of winter's greatest constellation, the Hunter whose form dominates the southern sky these January nights. The great variety of telescopic objects awaiting the astronomically curious in this large and prominent constellation explains the meaning of Barns' comment.

Looking first for variable stars, we find one in Orion's bright luminary, **Betelgeuse** (**Alpha** [α] **Orionis**). Betelgeuse is a red giant star some 520 light-years distant whose semi-regular pulsations cause a variation in its brightness of nearly one magnitude. Its period is roughly 5.7 years, over which time it ranges between magnitude 0.4 to 1.3.

The two other variables in Orion listed in our table are considerably less prominent. **W Orionis** is a long-period variable with a period of 212 days, ranging from about 5.9 to 7.7 in magnitude, while **BL Orionis** varies irregularly between magnitudes 6.3 and 6.9.

Turning to multiple stars, we find a wealth of stellar showpieces. **Beta** (β) **Orionis**, better known as the blue-white star **Rigel**, has a seventh-magnitude companion 10 arc-seconds away in position angle 202°, difficult to spot because of the primary's brightness.

Sigma (σ) **Orionis** is a striking stellar system consisting of no less than five components, although the two brightest members (3.9 and 5.9 in magnitude) are too close (0.3") for small telescopes to resolve. The remaining three can be seen easily in three and four-inch telescopes. Adding to the beauty of this scene is a second grouping known as **Struve 761**. This is an eighth to ninth magnitude trio of stars northwest of Sigma, with separations of 8 and 68 seconds of arc. Webb described this triple as a "beautiful little triangle." Pickering included the Sigma system in his list as one of the finest multiple stars. Have you seen it?

Zeta (ζ) **Orionis** is a triple system, the easternmost of the three stars forming Orion's belt — its proper name is **Alnitak**. The trio consists of a second magnitude primary and a fourth magnitude companion a tight two seconds of arc apart (position angle 164°), together with a tenth magnitude star 58 seconds away in position angle 10°. All three look blue-white to most observers — how do you find them? Zeta is also a convenient guide to the often photographed but seldom seen Horsehead Nebula, about one degree due south of the star.

The coarse open cluster **NGC-1981** is just north of the Great Nebula. This cluster is a wide scattering of a dozen or so stars spread out in an east-west direction over nearly a degree and including a number of unimpressive doubles. Although Pickering listed it as one of his "finest," most observers would agree that he has overrated this object. What do you think?

The small diffuse nebulosity **M-78** can be found by sweeping with a low-power eyepiece about one-fourth of the way along a line from Zeta to Betelgeuse. You can also pick it up by setting your telescope on Delta (δ) Orionis and sweeping due east to a point northeast of Zeta. A dim tenth magnitude, M-78 is illuminated by a pair of ninth magnitude stars separated by about 50 arc-seconds. Muirden called it a "faint concentration with a definite 'combed' structure," and Webb saw it as a "singular wispy *nebula*" and added "best defined north."

But the greatest glory of Orion is Barns' "supreme wonder of all supernal wonders" — the magnificent **Great Nebula** in Orion, consisting of M-42, M-43, and the multiple star Theta 1 Orionis (known as the Trapezium). The main nebulosity is designated M-42 with M-43 forming a northeast wing separated by a bridge of obscuring matter forming the dark "fishmouth" intrusion.

M-42 measures at least 66 by 60 minutes — over a degree — in extent, including its faint loops and filaments. **M-43** lies about seven minutes away and is a roughly circular patch 20 by 15 minutes in size surrounding a ninth magnitude star. Many observers never notice M-43 — or at least don't recognize it as such — because of the overpowering presence of M-42 itself.

Theta 1 (θ^1) **Orionis** — the Trapezium — consists of four stars of magnitudes 6.8, 7.9, 5.5, and 6.8 at separations ranging from 9 to 22 seconds. There are also two other closer members of about 11th magnitude, as well as several much fainter ones. All six have been glimpsed in good seeing with a three-inch refractor. The Trapezium ranks among the finest multiple stars in the sky for small instruments, and it appears on everyone's list. Its members look white on first inspection, but definite traces of color contrasts can be seen — especially in six inch and larger apertures.

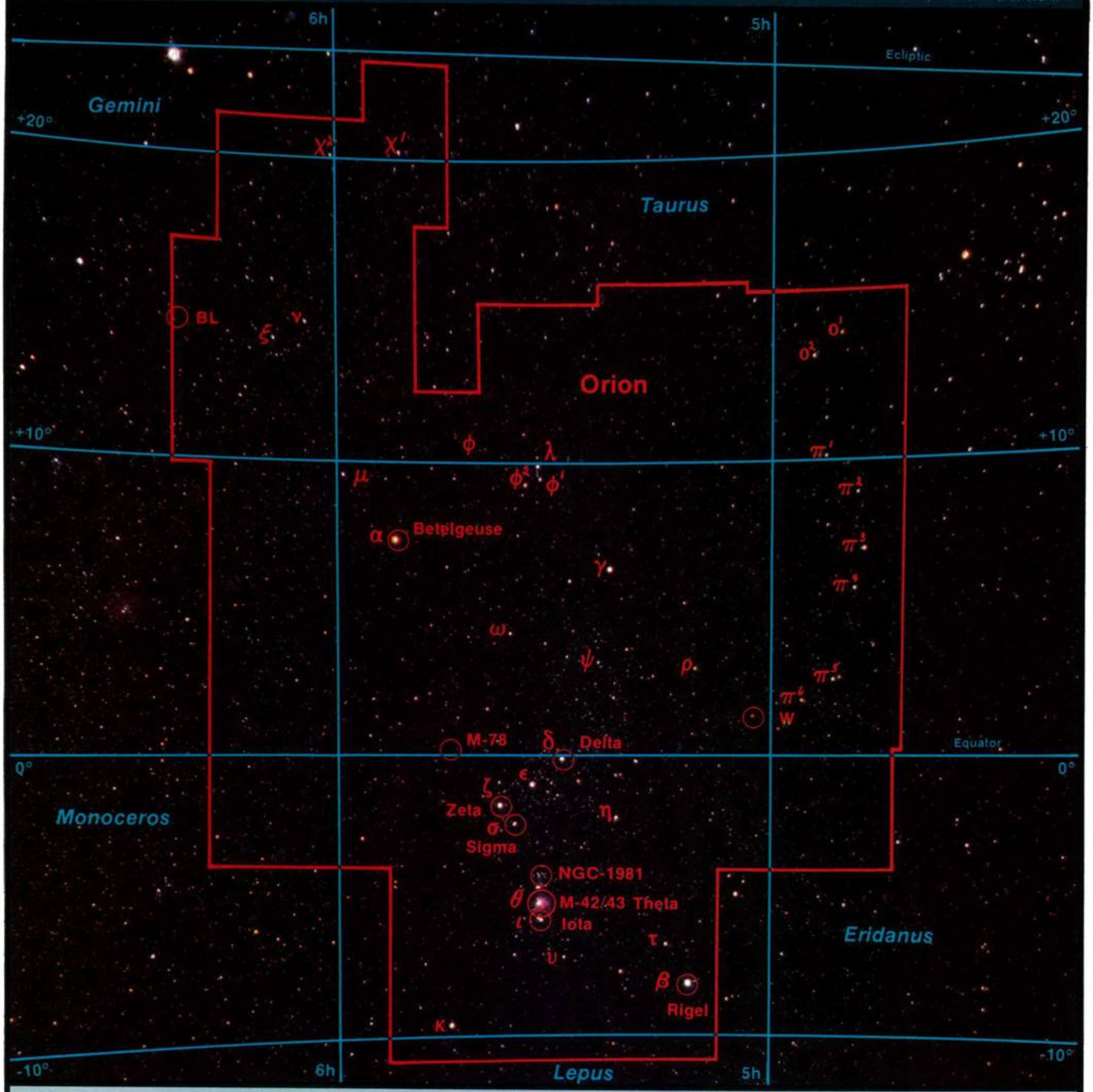
The Great Nebula complex takes magnification well, and any and all powers are useful here. To see the faint wispy outer extensions, use low power and sweep back and forth across the nebula for maximum contrast. Another technique is to place the nebula outside the eastern edge of a wide field of view and allow it to drift slowly across. Use of averted vision and a dark transparent night are also great helps. At 100 power or more with six-inch and larger telescopes, the brighter portions of the nebula, especially near the Trapezium, show a complex mottled structure.

The archeologist Sir W.M. Flinders Petrie once described Orion as "a star god of the myth-strewn firmament." Those who explore this great celestial figure with a telescope will find many reasons to agree!

Map by Dewey Schwartzenburg

orion

Photo by R. Provin & B. Wallis


6h
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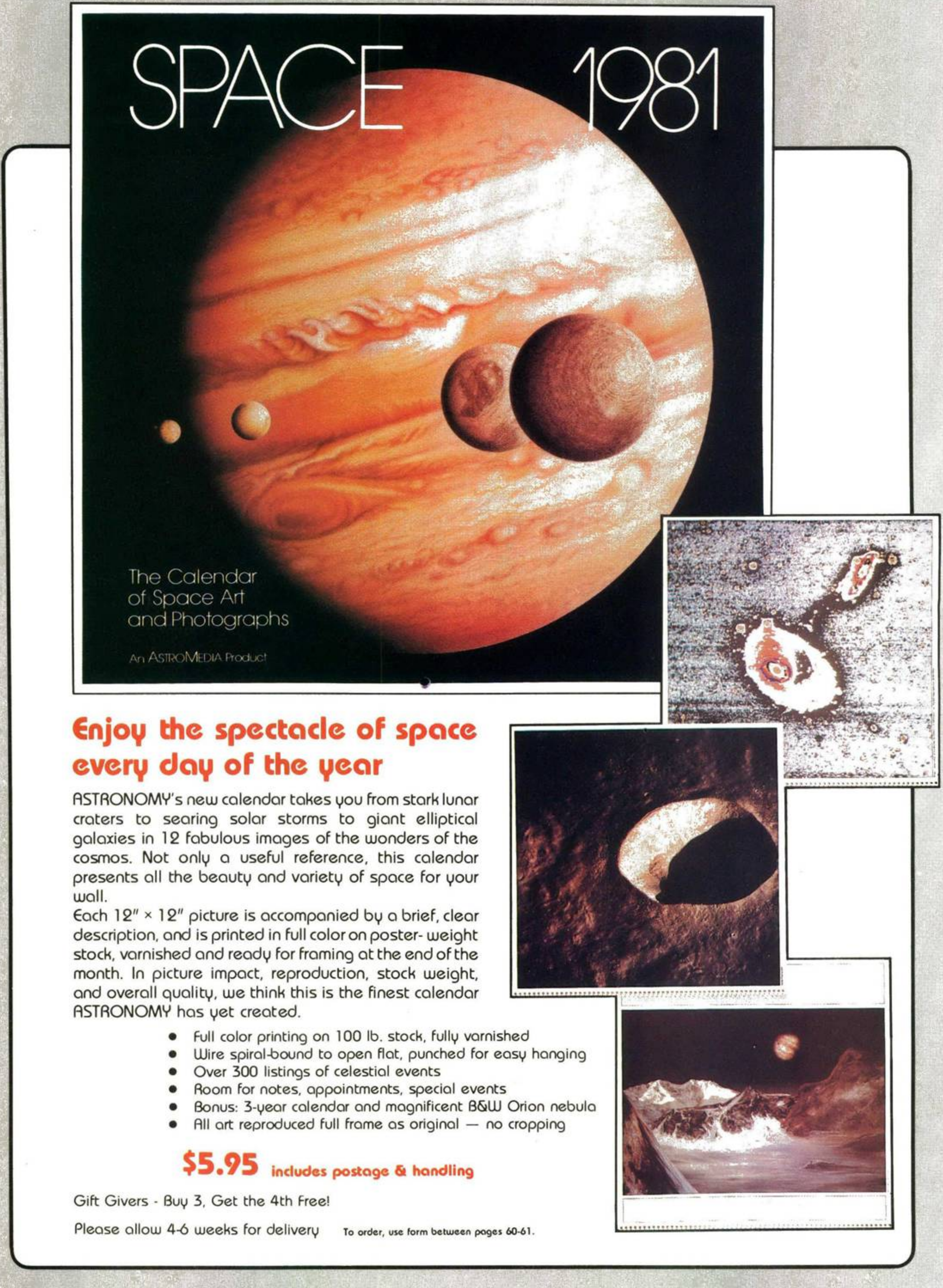
6h
Lepus
5h

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.	R.A. (1981)	Dec.
W	m★	5.9-7.7	212d	05 03	+01°07′	05 04	+01°09′
Beta (β)	$\star^2$	0.7,7.0	10″	05 12	-08°15′	05 14	-08°13′
Delta (δ)	$\star^2$	2.5,6.9	53″	05 29	-00°20′	05 31	-00°19′
NGC-1981	○	5	60′?	05 33	-04°52′	05 35	-04°51′
M-42	□	4	66′x60′	05 33	-05°25′	05 34	-05°24′
M-43	□	6	20′x15′	05 33	-05°56′	05 35	-05°55′
Theta^1 (θ^1)	$\star^4$	6.8,7.9, 5.4,6.8	9″,14″, 22″	05 33	-05°25′	05 34	-05°24′
Iota (θ)	$\star^2$	2.9,7.4	11″	05 33	-05°56′	05 35	-05°55′
Sigma (σ)	$\star^5$	3.9,5.9,7.2, 6.5,10	0.3″,13″, 42″,11″	05 36	-02°38′	05 38	-02°37′
Zeta (ζ)	$\star^3$	2.0,4.2,10	2.4″,58″	05 38	-01°58′	05 40	-01°57′
M-78	□	10	8′x6′	05 44	+00°02′	05 46	+00°03′
Alpha (α)	∩★	0.4-1.3	5-6y	05 52	+07°24′	05 54	+07°24′
BL	∩★	6.3-6.9	--	06 23	+14°45′	06 24	+14°44′

★	*Star*
$\star^2$	*Double Star*
$\star^3$	*Triple Star*
m★	*Regular Variable*
∩★	*Irregular Variable*
Ӿ★	*Eclipsing Variable*
○	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§∫	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*



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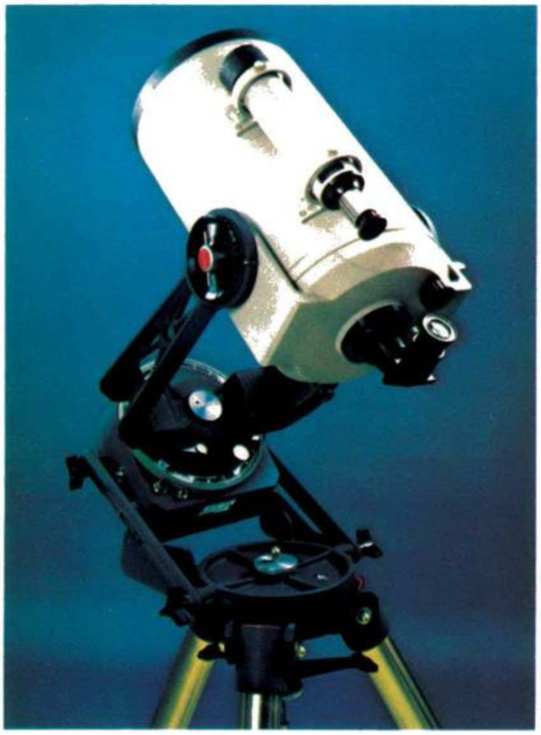

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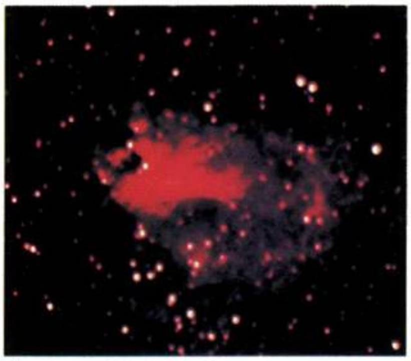

The Omega Nebula (M17) as photographed through the Dynamax 8.

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